STIC Search Report

EIC 3700

STIC Database Tracking Number: 183480

TO: Jerrold Johnson
Location: RND 9a54
Art Unit: 3728
Thursday, March 30, 2006

Case Serial Number: 10/748452

From: Edward Hart
Location: EIC-3700
Randolph – 8B21
Phone: 571-272-2512

edward.hart@uspto.gov

Search Notes

Examiner Johnson,

Attached are the results for the above search you requested.

I searched HCAPLUS, Medline, Biosis, Embase and Scisearch Databases, including the foreign patents databases WPIX, JAPIO.

Also, searched where the Dialog Full Text Patent Files as well as Dissertations, Conference Proceeding and the GALE Group Full Text Databases.

If you feel that the results are not on target please feel free to contact me so that I may refine your search.

Sincerely,
Edward Hart
Technical Information Specialist
EIC –3700 8B21
U.S. Patent & Trademark Office
Phone: 571-272-2512
edward.hart@uspto.gov

RUSH!

Access DB# 183480

SEARCH REQUEST FORM

Scientific and Technical Information Center

Requester's Full Name: Jerrold Johnson Examiner # : 80072 Date: 27/Mar 06
Art Unit: 3728 Phone Number ~~30~~2-7141 Serial Number: 10/748,452
Mail Box and Bldg/Room Location: RND 9a54 Results Format Preferred (circle): PAPER DISK E-MAIL

If more than one search is submitted, please prioritize searches in order of need.

****

Please provide a detailed statement of the search topic, and describe as specifically as possible the subject matter to be searched. Include the elected species or structures, keywords, synonyms, acronyms, and registry numbers, and combine with the concept or utility of the invention. Define any terms that may have a special meaning. Give examples or relevant citations, authors, etc, if known. Please attach a copy of the cover sheet, pertinent claims, and abstract.

Title of Invention: N/A

Inventors (please provide full names): N/A

Earliest Priority Filing Date: ______________

**For Sequence Searches Only* Please include all pertinent information (parent, child, divisional, or issued patent numbers) along with the appropriate serial number.*

Material Data sheets for Dow Calibre 2081

Examiner is interested in whether or not Dow makes specific recommendations w.r.t. the gamma sterilization of this material, in particular whether or not recommendations are provided w.r.t. exposure to oxygen during or post gamma radiation exposure

****

biocompatible plastics are favored because they survive in the body, others are formulated to disappear without a trace. Phi Gamma Jamma
... significant trend in the medical industry is a shift away from ethylene oxide (EtO) to **gamma radiation** as a way to sterilize packaged disposable devices such as syringes, catheters, and containers. Added...

...all plastics can be EtO sterilized, many turn yellow and are embrittled by Cobalt-60 **gamma-radiation sterilization**. As a result, most manufacturers are now offering radiation-resistant materials which exhibit less color...

...for instance, maintains its 4 ksi tensile strength after 5-Mrad exposure, double the normal **sterilization** dose. Stored at 72[deg.]F and 50% relative humidity for 4 yr after this...

...and 9234 for thermoforming are also stable after 5-Mrad exposure.
Chemical resistance, clarity, and **sterilization** flexibility prompted Cordis Corp., Miami Lakes, FL to select **Calibre** MegaRad 2081 from Dow Plastics, Midland, MI, for angioplasty-catheter components. This radiation-resistant **polycarbonate** exhibits 15 units color shift in yellowness index after 5-Mrad exposure, versus 30 units for unstabilized versions. Physical properties are maintained after this dose. Used for the **syringe** manifold, its clarity facilitates detection of bubbles. Good chemical resistance prevents attack by radiopaque dyes...

...ultrasonically, and molds easily in multicavity, hot-runner tools. Physical properties are retained after 5Mrad **gamma radiation**, though yellowing occurs. Characteristic of styrene acrylonitrile (SAN), however, clarity returns after 2 to 4...

...fighting additives such as morpholine. These additives can be especially hostile to transparent plastics, causing **discoloration** and **embrittlement**. Radel R, a polyphenylsulfone from Amoco has exceeded 2000 autoclave cycles in steam laced with...

...ppm morpholine without loss of mechanical properties. This material exhibits HDT of 400[deg.]F, **polycarbonate**-like Izod impact strength of 14 to 16 ft-lb/in. and is suggested for...

...Recently introduced medical grades Ultem 700 and Ultem 750 complement a line currently used in **sterilization** containers, nerve stimulators, biofilter-plate holders, reusable syringes, and ventilator valves. Surface Sulfonation
Reduced air...

...way into the patient's bloodstream. Treated surfaces can be sterilized with ethylene oxide or **gamma radiation** without loss of sulfonation.
Biological agents such as heparin can also be grafted to the sulfonated surface. This high-molecular-weight polysaccaride thins blood and prevents it from clotting. Currently patients who undergo open-heart surgery are injected with high doses of heparin to reduce clotting caused by blood contacting a foreign substance like plastic. The heparin is later neutralized by administration of protamine. Exposure to excessive bleeding or clotting are risks associated with this procedure. Using "heparinized" blood-handling equipment, however, the amount of heparin administered to the patient can be reduced or eliminated.
The sulfonation treatment consists

Dialog files

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? show files
File  16:Gale Group PROMT(R) 1990-2006/Mar 30
         (c) 2006 The Gale Group
File  98:General Sci Abs 1984-2004/Dec
         (c) 2005 The HW Wilson Co.
File 148:Gale Group Trade & Industry DB 1976-2006/Mar 29
         (c)2006 The Gale Group
File 149:TGG Health&Wellness DB(SM) 1976-2006/Mar W2
         (c) 2006 The Gale Group
File 160:Gale Group PROMT(R) 1972-1989
         (c) 1999 The Gale Group
File 441:ESPICOM Pharm&Med DEVICE NEWS 2006/Nov W1
         (c) 2006 ESPICOM Bus.Intell.
File 621:Gale Group New Prod.Annou.(R) 1985-2006/Mar 29
         (c) 2006 The Gale Group
File 636:Gale Group Newsletter DB(TM) 1987-2006/Mar 29
         (c) 2006 The Gale Group
? ds
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Set	Items	Description
S1	0	CALIBRE 2081
S2	10987	CALIBRE
S3	171107	OXYGEN
S4	1073	DIOXYGEN
S5	16212	SYRINGE
S6	197569	S2-S5
S7	2420	S6 AND (DISCOLOR? OR STERILIZATION)
S8	145	S7 AND (GAMMA (2N) RADIATION OR GAMMA (2N) STERILIZATION)
S9	25704	POLYCARBONATE
S10	71	S8 AND S9
S11	49	RD (unique items)
S13	7	S11 AND EMBRITTLEMENT
S14	6	S13 AND DISCOLOR?
S15	4	S14 AND S2

? t s15/3,k/1-4

15/3,K/1 (Item 1 from file: 148)
DIALOG(R)File 148:Gale Group Trade & Industry DB
(c)2006 The Gale Group. All rts. reserv.

05135830 SUPPLIER NUMBER: 10610320 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Prescription: plastics. (medical uses in and outside the body)
Stevens, Tim
Materials Engineering, v108, n4, p23(4)
April, 1991
ISSN: 0025-5319 LANGUAGE: ENGLISH RECORD TYPE: FULLTEXT
WORD COUNT: 2641 LINE COUNT: 00218

TEXT:

...Clarity and shatter resistance allow them t(, replace glass. New grades resist color change and **embrittlement** when exposed to **gamma-radiation sterilization**. Composites can be tailored to mimic the mechanical properties of bone in joint replacements. Patches and vascular grafts provide surgeons with body-repair parts that lock in place via tissue in-growth. Unlike metals, plastics are X-ray transparent, allowing a view of the healing process in bone repair. While some

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=> d his

     (FILE 'HOME' ENTERED AT 11:15:27 ON 30 MAR 2006)

     FILE 'WPIX' ENTERED AT 11:15:41 ON 30 MAR 2006
                E OXYGEN/CN
L1           17 S E3-11,E13-23,E25-28
                SEL DCSE
                EDIT ALL /DCSE /DCRE
L2        10498 E1-E17
                SEL SDCN L1
                EDIT ALL /SDCN /DCN
L3        18056 E18-34
                SEL SDRN L1
                EDIT ALL /SDRN /DRN
                E E35

     FILE 'REGISTRY' ENTERED AT 11:22:02 ON 30 MAR 2006
L4            1 S OXYGEN/CN

     FILE 'WPIX' ENTERED AT 11:22:25 ON 30 MAR 2006
L5       210901 S OXYGEN OR DIOXYGEN
                E OXYGEN OR DIOXYGEN
L6       214553 S L2-L3,L5
L7        75446 S B65B/IPC,IC,ICM,ICS,ICA,ICI
L8       250059 S B65D/IPC,IC,ICM,ICS,ICA,ICI
L9        78477 S Q31/DC
L10      129994 S Q34/DC
L11       10116 S A12-P/MC
L12       14542 S B11-C06/MC
L13        1702 S C11-C06/MC
L14          13 S A01N005-10/IPC
L15          44 S G01K011-30/IPC
L16         170 S G01V005-12/IPC
L17          37 S G01V005-14/IPC
L18        1118 S G21G004/IPC
L19         835 S G21K007/IPC
L20        7223 S K08-A/MC
L21        5785 S K08-E/MC
L22        1787 S S03-C03/MC
L23           9 S V05-E06/MC
L24         359 S V05-F01A3/MC
L25       15736 S L14-24
L26      336781 S L7-L13
L27          56 S L26 AND L25
L28           3 S L27 AND SYRINGE
L29         281 S L6 AND L25
L30           1 S L29 AND L26
L31           1 S L29 AND (SYRINGE OR DISCOLOR?)
L32           3 S L27 AND (SYRINGE OR DISCOLOR?)
L33           4 S L31 OR L32
L34           0 S CALIBRE 2081
L35        2717 S CALIBRE
L36        3733 S L26 AND (SYRINGE OR DISCOLOR? OR STERILIZATION)
L37        3733 S L36 AND L26
L38          27 S L25 AND (CALIBRE OR STERILIZATION)
L39          47 S L25 AND (CALIBRE OR STERILIZATION OR MEDICAL () DEVICE OR DIS
L40           2 S L25 AND CALIBRE
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=> => file hcaplus, medline, embase, biosis, scisearch
FILE 'HCAPLUS' ENTERED AT 14:47:52 ON 30 MAR 2006
USE IS SUBJECT TO THE TERMS OF YOUR STN CUSTOMER AGREEMENT.
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     (FILE 'HOME' ENTERED AT 14:35:50 ON 30 MAR 2006)
                SET COST OFF

     FILE 'HCAPLUS, MEDLINE, BIOSIS, EMBASE, SCISEARCH' ENTERED AT 14:37:53 ON
     30 MAR 2006
L1              0 S CALIBRE 2081
L2              0 S CALIBRE (5W) 2081
L3           5607 S CALIBRE
L4        1863669 S OXYGEN
L5          18765 S DIOXYGEN
L6          81708 S POLYCARBONATE
L7        1951696 S L4-L6
L8            626 S L3 AND L7
L9          36778 S SYRINGE
L10             1 S L8 AND L9
L11             0 S L8 AND (GAMMA (3W) RADIATION OR GAMMA (3W) STERILIZATION)
L12         28306 S EMBRITTLEMENT
L13        149533 S DISCOLOR? OR STERILIZATION
L14             2 S L8 AND L12
L15            13 S L8 AND L13
L16            13 DUP REM L15 (0 DUPLICATES REMOVED)

     FILE 'HCAPLUS, MEDLINE, EMBASE, BIOSIS, SCISEARCH' ENTERED AT 14:47:52 ON
     30 MAR 2006

=> d ibib ab l10 tot

L10  ANSWER 1 OF 1  SCISEARCH  COPYRIGHT (c) 2006 The Thomson Corporation  on
     STN
ACCESSION NUMBER:      2004:367222  SCISEARCH
THE GENUINE ARTICLE:   809PU
TITLE:                 Parametrically defined cerebral blood vessels as
                       non-invasive blood input functions for brain PET studies
AUTHOR:                Asselin M C (Reprint); Cunningham V J; Amano S; Gunn R N;
                       Nahmias C
CORPORATE SOURCE:      McMaster Univ, Dept Phys & Astron, Hamilton, ON L8S 4M1,
                       Canada (Reprint); Hammersmith Hosp, Hammersmith Imanet,
                       London, England; Gunma Univ, Sch Med, Dept Diagnost Radiol
                       & Nucl Med, Gunma, Japan; Montreal Neurol Inst, McConnell
                       Brain Imaging Ctr, Montreal, PQ, Canada; CPS Innovat,
```

Knoxville, TN USA
COUNTRY OF AUTHOR: Canada; England; Japan; USA
SOURCE: PHYSICS IN MEDICINE AND BIOLOGY, (21 MAR 2004) Vol. 49, No. 6, pp. 1033-1054.
ISSN: 0031-9155.
PUBLISHER: IOP PUBLISHING LTD, DIRAC HOUSE, TEMPLE BACK, BRISTOL BS1 6BE, ENGLAND.
DOCUMENT TYPE: Article; Journal
LANGUAGE: English
REFERENCE COUNT: 46
ENTRY DATE: Entered STN: 30 Apr 2004
Last Updated on STN: 30 Apr 2004
ABSTRACT IS AVAILABLE IN THE ALL AND IALL FORMATS

AB A non-invasive alternative to arterial blood sampling for the generation of a blood input function for brain positron emission tomography (PET) studies is presented. The method aims to extract the dimensions of the blood vessel directly from PET images and to simultaneously correct the radioactivity concentration for partial volume and spillover. This involves simulation of the tomographic imaging process to generate images of different blood vessel and background geometries and selecting the one that best fits, in a least-squares sense, the acquired PET image. A phantom experiment was conducted to validate the method which was then applied to eight subjects injected with 6-[F-18]fluoro-L-DOPA and one subject injected with [C-11]CO-labelled red blood cells. In the phantom study, the diameter of **syringes** filled with an 11C solution and inserted into a water-filled cylinder were estimated with an accuracy of half a pixel (I mm). The radioactivity concentration was recovered to 100 +/- 4% in the 8.7 mm diameter **syringe**, the one that most closely approximated the superior sagittal sinus. In the human studies, the method systematically overestimated the **calibre** of the superior sagittal sinus by 23 mm compared to measurements made in magnetic resonance venograms on the same subjects. Sources of discrepancies related to the anatomy of the blood vessel were found not to be fundamental limitations to the applicability of the method to human subjects. This method has the potential to provide accurate quantification of blood radioactivity concentration from PET images without the need for blood samples, corrections for delay and dispersion, co-registered anatomical images, or manually defined regions of interest.

=> d ibib ab l14 tot

L14 ANSWER 1 OF 2 HCAPLUS
ACCESSION NUMBER: 1995:599144 HCAPLUS
DOCUMENT NUMBER: 123:199949
TITLE: Conformational changes and physical aging in bisphenol-A **polycarbonate**: origins of mechanical properties
AUTHOR(S): Stolarski, V.; Letton, A.; Nour, E.; Laane, J.
CORPORATE SOURCE: Polymer Technology Consortium, Texas A and M Univ., College Station, TX, 77843-3255, USA
SOURCE: Annual Technical Conference - Society of Plastics Engineers (1994), 52nd(Vol. 2), 2077-80
CODEN: ACPED4; ISSN: 0272-5223
PUBLISHER: Society of Plastics Engineers
DOCUMENT TYPE: Journal
LANGUAGE: English
AB The long-term **embrittlement** without chemical degradation found in

Calibre and Lexan 141 is examined in terms of conformation and model compds. using wide-angle x-ray scattering and Raman difference spectroscopy.

L14 ANSWER 2 OF 2 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 1990:99449 HCAPLUS
DOCUMENT NUMBER: 112:99449
TITLE: Water sorption and hydrolytic stability of **polycarbonates**
AUTHOR(S): Golovoy, A.; Zinbo, M.
CORPORATE SOURCE: Sci. Res. Lab., Ford Mot. Co., Dearborn, MI, 48121, USA
SOURCE: Polymer Engineering and Science (1989), 29(24), 1733-7
CODEN: PYESAZ; ISSN: 0032-3888
DOCUMENT TYPE: Journal
LANGUAGE: English
AB The decrease in mol. weight of **Calibre** 300-15 **polycarbonate** by hydrolysis was a 1st order process under constant relative humidity (RH) and temperature Hydrolytic **embrittlement**, at mol. weight <34,000, was reached after .apprx.188, 143, 99, and 66 days under 56, 73, 87, and 95% RH, resp., at 100°. Water diffusivity was 8.7 + 10-7 cm2/s at 100°, with an activation energy of 7.9 kcal/mol. The equilibrium water sorption increased with temperature and RH. When samples immersed in water at 100° were transferred to room-temperature water, visible microcavities were formed, which became crack initiation sites under stress.

=> d ibib ab l16 tot

L16 ANSWER 1 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 2005:960204 HCAPLUS
DOCUMENT NUMBER: 143:249120
TITLE: Organic material compositions containing organosilanes with suppressed thermal degradation
INVENTOR(S): Miyake, Kunihito; Higo, Atsushi; Kikuchi, Taketoshi
PATENT ASSIGNEE(S): Sumitomo Pharmaceutical Co., Ltd., Japan
SOURCE: Jpn. Kokai Tokkyo Koho, 45 pp.
CODEN: JKXXAF
DOCUMENT TYPE: Patent
LANGUAGE: Japanese
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
JP 2005232258	A2	20050902	JP 2004-41068	20040218
PRIORITY APPLN. INFO.:			JP 2004-41068	20040218

AB The compns. contain organic silane compds. H(SiR1R2)l(SiR3R4)m(SiR5R6)nH (R1-6 = H, C1-30 organic compound residue, residue of compound having ≥1 Si; m ≥0; l, n ≥1; R1-R2-Si, R3-R4-Si, and R5-R6-Si may form C5-7 nonarom. ring, which may further form condensed ring with benzene ring). 1,1,2,2-Tetrakis(4-tert-butylphenyl)disilane and 1,1,2,2-tetrakis(4-phenylphenyl)disilane and the compns. containing them are also claimed. Thus, a composition comprising a **polycarbonate** (**Calibre**) and 1,1,2,2-tetraphenyldisilane was injection-molded at 360° to give a test piece showing suppressed yellowness.

L16 ANSWER 2 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN

ACCESSION NUMBER: 2004:819977 HCAPLUS
DOCUMENT NUMBER: 141:315165
TITLE: **Polycarbonate** compositions with improved thermal yellowing resistance
INVENTOR(S): Kikuchi, Taketoshi; Higo, Mutsuko
PATENT ASSIGNEE(S): Sumitomo Chemical Co., Ltd., Japan
SOURCE: Jpn. Kokai Tokkyo Koho, 17 pp.
CODEN: JKXXAF
DOCUMENT TYPE: Patent
LANGUAGE: Japanese
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
JP 2004277480	A2	20041007	JP 2003-67822	20030313
PRIORITY APPLN. INFO.:			JP 2003-67822	20030313

OTHER SOURCE(S): MARPAT 141:315165

AB The compns. contain diphosphine compds. A(p-C6H4PPh2)2 (A = direct link, O, S, sulfonyl, CO, Ph, sulfinyl, CR11R12, bicyclic hydrocarbon-type monoterpene residue, C5-8 cycloalkylidene which may be substituted by C1-8 alkyl or form condensed ring with 1-2 benzene ring; R11, R12 = H, Ph, C1-8 alkyl, C5-8 cycloalkyl, C5-8 alkylcycloalkyl) or their derivs. Thus, **polycarbonate** (**Calibre**) was mixed with 0.025 phr 4,4'-biphenylenebis(diphenylphosphine), melt kneaded at 340°, pelletized, and injection molded to give a sheet showing yellowness index 1.4.

L16 ANSWER 3 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 2004:310116 HCAPLUS
DOCUMENT NUMBER: 140:304733
TITLE: **Polycarbonate** compositions and color improvers therefor
INVENTOR(S): Fukuda, Kanako
PATENT ASSIGNEE(S): Sumitomo Chemical Co., Ltd., Japan
SOURCE: Jpn. Kokai Tokkyo Koho, 34 pp.
CODEN: JKXXAF
DOCUMENT TYPE: Patent
LANGUAGE: Japanese
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
JP 2004115568	A2	20040415	JP 2002-277058	20020924
PRIORITY APPLN. INFO.:			JP 2002-277058	20020924

OTHER SOURCE(S): MARPAT 140:304733

AB The compns. contain specified dihydroanthracene compds. and organic S compds. (RxOCOCH2CH2)2S and/or (RySCH2CH2CO2CH2)4C (Rx, Ry = C10-18 hydrocarbyl) as the color improvers. Thus, **polycarbonate** (**Calibre** 200-3) was blended with 0.025 phr 9,10-dihydroanthracene and 0.025 phr pentaerythrityl tetrakis(3-laurylthiopropionate), melt kneaded, pelletized, and injection molded at 340° to give a test piece showing yellowness index 0.7.

L16 ANSWER 4 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 2004:17921 HCAPLUS
DOCUMENT NUMBER: 140:60808
TITLE: Chemically- and heat-resistant polymer container parts

and containers with good transparency for perfumes for automobiles

INVENTOR(S): Fukawa, Norio
PATENT ASSIGNEE(S): Unitika Ltd., Japan
SOURCE: Jpn. Kokai Tokkyo Koho, 11 pp.
CODEN: JKXXAF
DOCUMENT TYPE: Patent
LANGUAGE: Japanese
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.		DATE
JP 2004002609	A2	20040108	JP 2002-215244		20020724
PRIORITY APPLN. INFO.:			JP 2002-102608	A	20020404

AB The parts contain (A) 100 parts blends comprising 20-60 parts polyarylates and/or **polycarbonates** and 40-80 parts polyesters comprising dicarboxylic acids mainly comprising terephthalic acid (I) and diols containing ≥70 mol% 1,4-cyclohexanedimethanol (II) and (B) 0.01-0.3 part phosphates as yellowing prevention agents during molding. Thus, pellets comprising D Powder (polyarylate) 60, Thermx 6761 (95:100:5 I-II-isophthalic acid copolymer) 40, and JP 504 (alkyl phosphate) 0.05 part was injection-molded at 300° to give a test piece showing deflection temperature under load 130°, yellowing index 9, and neither crack nor distortion after exposure to a fragrance at 80° for 24 h.

L16 ANSWER 5 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 2003:443943 HCAPLUS
DOCUMENT NUMBER: 139:23038
TITLE: Woody compositions having no **discoloration** and their moldings as wood substitutes
INVENTOR(S): Sugimoto, Ryuichi; Ito, Masanori; Kojima, Junpei; Matsuzaki, Hidetaka; Ootomo, Yoshinori
PATENT ASSIGNEE(S): Nippon A and L Co., Ltd., Japan
SOURCE: Jpn. Kokai Tokkyo Koho, 7 pp.
CODEN: JKXXAF
DOCUMENT TYPE: Patent
LANGUAGE: Japanese
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
JP 2003165909	A2	20030610	JP 2001-366116	20011130
PRIORITY APPLN. INFO.:			JP 2001-366116	20011130

AB Compns. comprise thermoplastic resins selected from methacrylic resins, **polycarbonates**, rubber-reinforced acrylonitrile-styrene copolymer, and saturated polyesters 100, powdered cellulose having whiteness 65-95% 1-100, and pigments 0.1-5 parts. Thus, a composition containing 100 parts ethylene-propylene-type rubber-reinforced acrylonitrile-styrene copolymer (UB 311) and 30 parts powdered cellulose (KC Flock W 100) was extruded to give a sheet showing gloss 6.5.

L16 ANSWER 6 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 2003:111072 HCAPLUS
DOCUMENT NUMBER: 138:154391
TITLE: **Polycarbonate** resin compositions containing surface-treated titanium oxide with good thermal stability and mechanical strength

INVENTOR(S): Sato, Ichiro; Okada, Koji; Nukui, Shinji
PATENT ASSIGNEE(S): Sumitomo Dow Limited, Japan
SOURCE: Jpn. Kokai Tokkyo Koho, 5 pp.
CODEN: JKXXAF
DOCUMENT TYPE: Patent
LANGUAGE: Japanese
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
JP 2003041109	A2	20030213	JP 2001-230920	20010731
PRIORITY APPLN. INFO.:			JP 2001-230920	20010731

AB Title compns. comprise 100 parts **polycarbonate** resins and 0.03-5 parts polyene phosphoric acid compound-surface treated titanium oxide. Thus, a composition comprising 100 parts **Calibre** 200-10 and 1 part polyene phosphoric acid compound-surface treated titanium oxide was kneaded at 280° and injection-molded to give a test piece with impact strength 80 kg-cm/cm, total light transmittance <1%, yellow index 1, and mol. weight loss ratio after molding at 340° 6.3%.

L16 ANSWER 7 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 2002:792363 HCAPLUS
DOCUMENT NUMBER: 137:311953
TITLE: Polyarylate compositions with good heat and impact resistance and their injection and extrusion moldings
INVENTOR(S): Fukawa, Norio
PATENT ASSIGNEE(S): Unitika Ltd., Japan
SOURCE: Jpn. Kokai Tokkyo Koho, 8 pp.
CODEN: JKXXAF
DOCUMENT TYPE: Patent
LANGUAGE: Japanese
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
JP 2002302596	A2	20021018	JP 2001-108569	20010406
PRIORITY APPLN. INFO.:			JP 2001-108569	20010406

AB The compns. contain (A) 10-90 parts polyarylates and (B) 10-90 parts polyesters manufactured from dicarboxylic acids containing ≥50-100 mol% terephthalic acid and diols containing ≥50-100 mol% 1,4-cyclohexanedimethanol. Thus, a composition comprising D Powder (polyarylate) 40, terephthalic acid-1,4-cyclohexanedimethanol copolymer 60, and JP 504 (Bu phosphate) 4, and PEP 36 [pentaerythritol bis[(2,6-di-tert-butyl-4-methylphenyl)phosphite]] 0.05 part was injection-molded at 280° to give a test piece showing Izod impact value 600, deflection temperature 115° under 0.46 MPa-load, total light transmittance 85%, and yellowing index 10.

L16 ANSWER 8 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 2002:707337 HCAPLUS
DOCUMENT NUMBER: 137:233430
TITLE: Polyarylate resin composition with **discoloration** resistance
INVENTOR(S): Yamamoto, Akira; Kamikawa, Yasuo
PATENT ASSIGNEE(S): Unitika Ltd., Japan
SOURCE: Jpn. Kokai Tokkyo Koho, 7 pp.
CODEN: JKXXAF

DOCUMENT TYPE: Patent
LANGUAGE: Japanese
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
JP 2002265766	A2	20020918	JP 2001-67086	20010309
PRIORITY APPLN. INFO.:			JP 2001-67086	20010309

AB Title composition comprises an aromatic polyester resin, optionally a **polycarbonate** resin, a phenolic compound, a P-containing compound, and a lactone-type compound

L16 ANSWER 9 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 2000:881229 HCAPLUS
DOCUMENT NUMBER: 134:42961
TITLE: **Polycarbonate** compositions stabilized against **discoloration** and physical property deterioration during **sterilization** by ionizing radiation, their production and their use
INVENTOR(S): Sleeckx, Jozef Julius
PATENT ASSIGNEE(S): Dow Chemical Company, USA
SOURCE: PCT Int. Appl., 21 pp.
CODEN: PIXXD2
DOCUMENT TYPE: Patent
LANGUAGE: English
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.		DATE
WO 2000075223	A1	20001214	WO 2000-US9114		20000406
W: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, YU, ZA, ZW, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM					
RW: GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW, AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG					
US 6166116	A	20001226	US 1999-325249		19990603
EP 1198505	A1	20020424	EP 2000-921761		20000406
EP 1198505	B1	20040107			
R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, SI, LT, LV, FI, RO, MK, CY, AL					
JP 2003501535	T2	20030114	JP 2001-502500		20000406
PRIORITY APPLN. INFO.:			US 1999-325249	A	19990603
			WO 2000-US9114	W	20000406

OTHER SOURCE(S): MARPAT 134:42961
AB **Polycarbonate** compns. containing a poly(oxyalkylene) derivative, a free disulfonimide, and optionally a salt exhibit good color stability and phys. property retention when irradiated with ionizing radiation for **sterilization** and are suitable for use in medical goods. Examples were provided which contained bisphenol A **polycarbonate**, polypropylene glycol or polyoxyethylene monoallyl ether, and N-(p-tolylsulfonyl)-p-toluenesulfonamide or its K salt.
REFERENCE COUNT: 4 THERE ARE 4 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L16 ANSWER 10 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 1999:114226 HCAPLUS
DOCUMENT NUMBER: 130:183316
TITLE: Surface-treated white pigments for **polycarbonates** for preventing yellowing and lowering of molecular weight
INVENTOR(S): Yoshioka, Hiroshi; Sato, Ichiro; Nukui, Shinji
PATENT ASSIGNEE(S): Sumitomo Dow K. K., Japan; Sumitomo Dow Limited
SOURCE: Jpn. Kokai Tokkyo Koho, 4 pp.
CODEN: JKXXAF
DOCUMENT TYPE: Patent
LANGUAGE: Japanese
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
JP 11043597	A2	19990216	JP 1997-219233	19970729
JP 3649424	B2	20050518		
PRIORITY APPLN. INFO.:			JP 1997-219233	19970729

AB The title compns. contain 100 parts **polycarbonates** and 0.01-40 parts inorg. white pigments whose surface is treated with 0.1-10% (based on the pigments) polyorganosiloxanes having epoxy, carboxy, or silanol groups. Thus, 100 parts TiO_2 was treated with 3 part carboxy-modified polyorganosiloxane (BY 16-750) to give a pigment, 0.05 part of which was kneaded with 100 parts **polycarbonate** (**Calibre** 200-20) and extruded to pellets showing lowering of mol. weight 100, yellowing index 2.2, and good appearance.

L16 ANSWER 11 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 1996:713207 HCAPLUS
DOCUMENT NUMBER: 125:330569
TITLE: Vehicle exterior body panels prepared from diaryl fluorene **polycarbonate**
INVENTOR(S): Bales, Stephen E.
PATENT ASSIGNEE(S): Dow Chemical Company, USA
SOURCE: PCT Int. Appl., 27 pp.
CODEN: PIXXD2
DOCUMENT TYPE: Patent
LANGUAGE: English
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
WO 9629365	A1	19960926	WO 1995-US16079	19951213
W: JP				
RW: AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE				
PRIORITY APPLN. INFO.:			US 1995-407935 A	19950321

AB Exterior body panels for vehicles are prepared consisting essentially of (I) a carbonate polymer composition consisting essentially of (Ia) a diaryl fluorene carbonate polymer component, and optionally, (Ib) a second, different carbonate polymer component; the carbonate polymer compn (I) having an inherent viscosity as determined at 25°C in methylene chloride at a polymer concentration of 0.5 g/dL in the range of 0.30-0.47 dL/g and comprising from 10-50 mol% diaryl fluorene moieties based on the total moles of multihydric diaryl fluorene and addnl. multihydric compound remnant moieties in the carbonate polymer composition Also shown is a process for

preparing such injection molded, vehicle exterior body panels. In particular, the injection speed in the process must be maintained below a certain critical level to provide excellent part appearance and avoid splay and **discoloration** effects in the parts. Exterior body panels can be injection molded for a range of vehicles including automobiles, trucks, recreational vehicles, and mobile homes, where these combinations of processability, heat resistance, toughness, light weight and recyclability are desired. Thus, injection molding a mixture of 75% 9,9-bis(4-hydroxyphenyl)fluorene-bisphenol A-phosgene copolymer (Mw 27,000; viscosity 0.36 dL/g) and 25% bisphenol A-phosgene copolymer (melt flow rate 3.5 g/10 min) gave an extrudate having impact resistance 370 in-lb at 23° and 345 in-lb at -29°.

L16 ANSWER 12 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 1996:521414 HCAPLUS
DOCUMENT NUMBER: 125:197234
TITLE: The changes in ethylene oxide **sterilization** and their effect on thermoplastics
AUTHOR(S): Navarrete, Lisa; Hermanson, Nancy
CORPORATE SOURCE: Dow Plastics, USA
SOURCE: Annual Technical Conference - Society of Plastics Engineers (1996), 54th(Vol. 3), 2807-2818
CODEN: ACPED4; ISSN: 0272-5223
PUBLISHER: Society of Plastics Engineers
DOCUMENT TYPE: Journal
LANGUAGE: English

AB A study of the effect of three ethylene oxide (I) **sterilization** systems, e.g., Oxyfume 2000, a mixture of I and HCFC-12, Oxyfume 2002, a mixture of I, HCFC-124 and HCFC-22, and pure I, on the phys. properties of 14 different families of resins showed that general purpose polystyrene (Styron 666D), high-impact polystyrene (Styron 478), advanced styrene resin (Aim 4800), styrene-acrylonitrile copolymer (Tyril 1000B), and low-gloss acrylonitrile-butadiene-styrene copolymer (Magnum 2642) contained visible signs of chemical attack after exposure to each I sterilant system. The attack appeared as tiny hairline cracks in the transparent materials and as fine scuff marks in the opaque resins. Based on the phys. property data, I is considered to be a viable **sterilization** method, but care should be taken to avoid over exposure. After 8 wk, the break elongation of Styron 478 and Aim 4800 decreased by at least 50% with multiple exposures to all three sterilants. The impact energy is significantly reduced for both resins after exposure to HCFC-124 and HCFC-124/HCFC-22; this is attributed to crosslinking of the butadiene rubber particles resulting in a loss of ductility. High-d. polyethylene (HDPE 25455) and polypropylene (Montel 6323 NT) samples showed a significant increase in break elongation after exposure to all three gases. The phys. properties of Magnum 2620 and Magnum 2642 ABS polymers, **Calibre** 2061 **polycarbonate**, Isoplast 2530 rigid thermoplastic polyurethane, Dural 725C2H PVC, Zytel 101 polyamide, and ICI 61 IBCL acrylic resin were not significantly affected by any of the three sterilant gases. The three tested I sterilant gases indicate minimal differences in their effect on the phys. and visual properties of thermoplastics. The two new gases evaluated, HCFC-124/HCFC-22, and pure I are comparable to HCFC-124, a current standard for I **sterilization.**

L16 ANSWER 13 OF 13 HCAPLUS COPYRIGHT 2006 ACS on STN
ACCESSION NUMBER: 1991:681320 HCAPLUS
DOCUMENT NUMBER: 115:281320
TITLE: Styren copolymer molding compositions having improved color stability

INVENTOR(S): Gkogkidis, Antonios
PATENT ASSIGNEE(S): Dow Chemical Co., USA
SOURCE: PCT Int. Appl., 59 pp.
CODEN: PIXXD2
DOCUMENT TYPE: Patent
LANGUAGE: English
FAMILY ACC. NUM. COUNT: 3
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.		DATE
WO 9111487	A1	19910808	WO 1991-US673		19910128
W: AU, BR, CA, JP, KR					
RW: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LU, NL, SE					
CA 2050684	AA	19910803	CA 1991-2050684		19910128
AU 9172571	A1	19910821	AU 1991-72571		19910128
EP 466906	A1	19920122	EP 1991-904315		19910128
R: BE, DE, ES, FR, GB, IT, NL, SE					
BR 9104236	A	19920804	BR 1991-4236		19910128
JP 04504590	T2	19920813	JP 1991-504490		19910128
EP 442633	A1	19910821	EP 1991-300712		19910130
R: BE, DE, ES, FR, GB, IT, NL, SE					
CA 2035509	AA	19910803	CA 1991-2035509		19910201
AU 9170161	A1	19910808	AU 1991-70161		19910201
BR 9100429	A	19911022	BR 1991-429		19910201
JP 04213350	A2	19920804	JP 1991-31386		19910201
US 5196461	A	19930323	US 1991-760553		19910916
PRIORITY APPLN. INFO.:			US 1990-474171	A	19900202
			US 1990-474415	A	19900202
			US 1990-474416	A	19900202
			WO 1991-US673	A	19910128

AB Title compns. comprise a monovinylidene aromatic copolymer, an acetal polymer, oxirane-containing stabilizer, and optionally an elastomer. Thus, a 20:23:17:30 Kematal M 25 (acetal copolymer)-ABS-Pellethane 235-80A (polyester-polyurethane elastomer)-**Calibre** 200-20 (**polycarbonate**) blend containing 5% Plastipon 655 (epoxidized soybean oil) as stabilizer showed good **discoloration** resistance than a similar blend containing no stabilizer.

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         (c) 2006 Elsevier Science Ltd.
File 315:ChemEng & Biotec Abs 1970-2006/Feb
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File 285:BioBusiness(R) 1985-1998/Aug W1
         (c) 1998 BIOSIS
File 357:Derwent Biotech Res. _1982-2006/Mar W4
         (c) 2006 Thomson Derwent & ISI
File 358:Current BioTech Abs 1983-2006/Jan
          (c) 2006 DECHEMA
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Set     Items   Description
S1          0   CALIBRE (2N) 2081
S2        153   CALIBRE
S3      75608   OXYGEN
S4        831   DIOXYGEN
S5       2391   SYRINGE
S6      76118   S2-S4
S7         53   S6 AND S5
S8          0   S7 AND (DISCOLOR? OR STERILIZATION)
S9        342   S6 AND (DISCOLOR? OR STERILIZATION)
S10         0   S9 AND S5
S11        38   S9 AND (PACKAGING OR MEDICAL (2N) DEVICE OR APARAT?)
S13         1   S11 AND S12
S14        35   S9 AND (GAMMA OR RADIATION)
S15         3   S11 AND S14
S16      2918   S6 AND (GAMMA OR RADIATION)
S17        35   S16 AND (DISCOLOR? OR STERILIZATION)
S18         3   S17 AND (PACKAGING OR MEDICAL (2N) DEVICE OR APARAT?)
S19         0   CALIBRE (2N) 2061
S20         0   S2 AND GAMMA (2N) RADIATION
S21         0   S2 AND (GAMMA (2N) STERILIZATION OR SYRINGE)
S22         0   S2 AND (GAMMA (2N) STERILIZATION)
S23         0   S2 AND STERILIZATION
S24         0   S2 AND DISCOLOR?
S25      3388   S2 AND OXYGEN OR DIOXYGEN OR POLYCARBONATE
S26         0   S24 AND STERILIZATION
S27        22   S25 AND STERILIZATION
S28         1   S27 AND (DISCOLOR? OR MEDICAL (2N) DEVICE OR APPRAT?)
S29         0   S27 AND EMBRITTLEMENT
S30        53   S7 NOT S28
S31        19   RD S27  (unique items)

? t s31/3,k/1-19

 31/3,K/1     (Item 1 from file: 35)
DIALOG(R)File  35:Dissertation Abs Online
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01637155  ORDER NO: AAD98-26665
DEVELOPMENT OF TECHNOLOGIES LEADING TO RECHARGEABLE IMPLANTABLE GLUCOSE
BIOSENSORS
  Author:  YANG, SAIPENG
```

Degree: PH.D.
Year: 1998
Corporate Source/Institution: THE UNIVERSITY OF NEW MEXICO (0142)
Source: VOLUME 59/03-B OF DISSERTATION ABSTRACTS INTERNATIONAL.
PAGE 1243. 168 PAGES

...or surgical access. The sensor also could be refilled with fresh immobilized enzyme after standard **sterilization** procedures.

Oxygen detection based amperometric measurement has been utilized due to its linear dependence of...

...of interference from normal physiological substrates. Different glucose/oxygen diffusion membranes (sandwich type membranes, annealed **polycarbonate** (PC) membranes, and Silastic$\sp\circler$ coated polytetrafluoroethylene (PTFE) membranes) have been developed and examined. Various in vitro tests were conducted to evaluate the performance of sensors with different diffusion membranes. These tests include the calibration test (in model buffer solutions and undiluted bovine blood plasma), evaluation of the effect of potential physiological interference, signal reproducibility, and the long-term operational performance. In vitro results suggest that annealed PC membranes have the advantages of good reproducibility, as well as ease of fabrication, and thus were utilized for in vivo application.

An integrated implantable system consisting of a glucose biosensor (with glucose oxidase), an oxygen sensor (without glucose oxidase), a miniature potentiostat, a power supply, and a signal acquiring device was subcutaneously implanted in healthy mongrel dogs. The results of acute subcutaneous implantation of the integrated system showed good agreement between the glucose concentration measured by the biosensor and that obtained using standard glucose determination methods. During chronic implantation the biosensor was successfully refilled in vivo. A rejuvenation of the sensor's response after refilling was observed suggesting the potential of such sensors for long-term implantation.

The studies in this dissertation suggest that the sensors have the good potential for long-term implantation, however, further work are needed to improve the sensor lifetime. More investigations on hysteresis, sensor miniaturization and biocompatibility are suggested for the later studies.

31/3,K/2 (Item 2 from file: 35)
DIALOG(R)File 35:Dissertation Abs Online

01347000 ORDER NO: AAD13-42127
MECHANICAL AND ULTRASONIC SWAGING STUDIES OF ABS, **POLYCARBONATE** AND PC/PCTG BLEND
Author: CADAVID, CARLOS
Degree: M.S.
Year: 1990
Corporate Source/Institution: UNIVERSITY OF MASSACHUSETTS AT LOWELL (0111)
Source: VOLUME 29/02 of MASTERS ABSTRACTS.
PAGE 318. 154 PAGES

MECHANICAL AND ULTRASONIC SWAGING STUDIES OF ABS, **POLYCARBONATE** AND PC/PCTG BLEND

ABS, **polycarbonate** and a PC/PCTG blend were evaluated in mechanical and ultrasonic cold forming (swaging) processes...

...evaluated. After the forming operation, the specimen was subjected to the combination of gamma/EtO **sterilization** processes.

Drying of specimens before swaging and swaging speed were analyzed for mechanical swaging. A ranking system was used for visual analysis before and after **sterilization**. The quality of swaging was measured using the rubber septum push out load. A solvent cracking resistance relationship between annealed ASTM specimens with regular geometry and prototype specimens with complex geometry was investigated. Similar studies were performed on ultrasonically swaged specimens. Also, the effects of moisture on melt viscosity of the polymers were studied.

31/3,K/3 (Item 1 from file: 315)
DIALOG(R)File 315:ChemEng & Biotec Abs

516282 CEABA Accession No.: 34-12-005126 DOCUMENT TYPE: Journal
Title: Determination of compounds inhibiting bacterial growth in sterilized medical devices
AUTHOR: Shintani, H. ; Suzuki, E. ; Sakurai, M.
CORPORATE SOURCE: Nat. Inst. of Health Sciences, Tokyo, J Japan Waters Co. Ltd., Tokyo, J Ishikawajima Harima Heavy Industry Co. Ltd., Kanagawa, J
JOURNAL: Chromatographia, Volume: 58, Issue: 3-4, Page(s): 193-199
CODEN: CHRGB7 ISSN: 00095893
PUBLICATION DATE: 2003 (20030000)

...ABSTRACT: ware are often made of polymers, the most common among them being polysulfone (PS) and **polycarbonate** (PC). The PS is produced by the condensation of 4,4'-dichlorodiphenyl sulfone and bisphenol...

... be considered during the medical application of these polymers is to verify their safety upon **sterilization**. Upon **sterilization** by autoclaving or ozone treatment some polymers release toxic byproducts that can have damaging side...

... a study conducted to evaluate and identify the compounds that cause bacterial growth inhibition after **sterilization** of these polymers. The authors assessed the degree of bacterial inhibition in both spore forming...

...also used sophisticated analytical techniques for determining the nature and quantity of chemicals released upon **sterilization**. Their study showed the formation of 4-chloro-4'-hydroxydiphenyl sulfone upon treatment of PS...

... authors recommend the use of polyvinylidene difluoride (PVDF) in the manufacture of medical ware, since **sterilization** does not lead to the generation of any toxic intermediates in this polymer.
DESCRIPTORS: **sterilization** ; **polycarbonate** ; polysulfone ; spectroscopy ; liquid chromatography ; autoclave ; toxicity hazard
DESCRIPTORS: Sterilisation ; **Polycarbonate** ; Polysulfone

31/3,K/4 (Item 2 from file: 315)
DIALOG(R)File 315:ChemEng & Biotec Abs

470942 CEABA Accession No.: 31-06-000303 DOCUMENT TYPE: Journal

Title: Water permeability of polymers under a high concentration gradient and concentration polarisation. -Pt. II
Orig. Title: Wasserdurchlaessigkeit von Polymeren unter einem hohen Konzentrationsgradienten und bei Konzentrationspolarisation.-Tl.2
AUTHOR: Grigoryants, I.K. ; Trikhanova, G.A.
CORPORATE SOURCE: Moskauer Staatliche Industrieuniversitaet, Moskau, Russia NTTs "Osmos", Moskau, Russia
JOURNAL: Plast. Massy, Issue: 12, Page(s): 29-40
CODEN: PLMSAI ISSN: 05542901
PUBLICATION DATE: 1999 (19990000) LANGUAGE: Russian

...ABSTRACT: 25 to 45degC on water permeation and separation rate. Studies of block copolymers include polyetherurethanes, **polycarbonate** siloxanes, copolymers of ethylene and vinyl acetate. Composition, structural and chemical characteristics of the polymer have considerable effect on water permeability. The effect of **sterilization** by irradiation on the permeability of polymer membranes is discussed for membranes based on cellulose acetobutyrate, polyamides or polyetherurethanes. Membrane performance is evaluated for different osmotic agents considering the effect of concentration, water transport in relation to polymer membrane macrostructure and microstructure, sorption and diffusion characteristics.

31/3,K/5 (Item 3 from file: 315)
DIALOG(R)File 315:ChemEng & Biotec Abs

446538 CEABA Accession No.: 29-11-018590 DOCUMENT TYPE: Journal
Title: Effects of γ-irradiation on some properties of durolon **polycarbonate.**
AUTHOR: Araujo, E. S. ; Khoury, H. J. ; Silveira, S. V.
CORPORATE SOURCE: Univ. Federal Pernambuco Dept. Energia Nuclear 50740-540 Recife-PE Brazil
JOURNAL: Radiat. Phys. Chem., Volume: 53, Issue: 1, Page(s): 79-84
CODEN: RPCHDM ISSN: 0969806X
PUBLICATION DATE: Jul 1998 (980700) LANGUAGE: English

Title: Effects of γ-irradiation on some properties of durolon **polycarbonate.**
ABSTRACT: On γ-irradiation, amorphous Brazilian bisphenol-A **polycarbonate** (Durolon) underwent main-chain scissions, resulting in a decrease in molecular weight and yellowing of...

... a dose of 100 kGy, indicating that medical supplies made of Durolon can withstand 4 **sterilization** irradiations.

31/3,K/6 (Item 4 from file: 315)
DIALOG(R)File 315:ChemEng & Biotec Abs

436785 CEABA Accession Number: 29-05-008801 DOCUMENT TYPE: Journal
Title: Investigations of fouling mechanisms governing permeate flux in the crossflow microfiltration of beer.
AUTHOR: Blanpain, P. ; Lalande, M.
CORPORATE SOURCE: Inst. Natl. Rech. Agronomique (INRA) Lab. Genie Procedes Technol. Alimentaires (LGPTA) F-59651 Villeneuve d'Ascq France
JOURNAL: Filtr. Sep., Volume: 34, Issue: 10, Page(s): 1065-1069

CODEN: FSEPAA ISSN: 00151882
PUBLICATION DATE: Dec 1997 (971200) LANGUAGE: English

...ABSTRACT: for the crossflow microfiltration (CMF) of beer. Two downstream membrane processes were involved: clarification and **sterilization** of beer. Fouling mechanisms were interpreted and compared for 2 types of beer (clarified beer and rough beer), filtered through a track-etched 0.2 µm **polycarbonate** membrane. Flux decay was analysed using a combination of constant pressure blocking filtration laws with measurement of membrane resistances arranged in series. For both types of beer, the permeate flux was governed by two identical fouling mechanisms: an internal fouling of pores in the initial stages of filtration that conforms to the standard blocking model, followed by an external surface fouling conforming to the cake filtration model. The predominant membrane resistance arises from the build-up of a loosely bound and reversible fouling layer over the membrane surface (representing more than 80% of the total filtration resistance). Macrosolutes and colloids are likely to be involved both in the progressive pore plugging and in the external fouling layer, because of their high tendency to interact with porous material.

31/3,K/7 (Item 5 from file: 315)
DIALOG(R)File 315:ChemEng & Biotec Abs

418418 CEABA Accession No.: 28-07-015703 DOCUMENT TYPE: Journal
Title: Growth physiology of the hyperthermophilic archaeon Thermococcus litoralis: development of a sulfur-free defined medium, characterization of an exopolysaccharide, and evidence of biofilm formation.
AUTHOR: Kelly, R. M. ; Rinker, K. D.
CORPORATE SOURCE: North Carolina State Univ. Dept. Chem. Eng. Raleigh, NC 27695-7905 USA
JOURNAL: Appl. Environ. Microbiol., Volume: 62, Issue: 12, Page(s): 4478-4485
CODEN: AEMIDF ISSN: 00992240
PUBLICATION DATE: Dec 1996 (961200) LANGUAGE: English

...ABSTRACT: exopolysaccharide appeared to have a role in the formation of biofilms by T. litoralis on **polycarbonate** filters and glass slides.
DECHEMA CLASSIFICATION CODE AND HEADING:
(High-molecular products (enzymes, hormones, peptides, etc.))
(Bacteria, cyanobacteria (Prokaryota))
(Preparation and **sterilization** of nutrient media)

31/3,K/8 (Item 6 from file: 315)
DIALOG(R)File 315:ChemEng & Biotec Abs

405908 CEABA Accession No.: 28-02-003144 DOCUMENT TYPE: Journal
Title: A new generation of dispersers/emulsifiers.
Orig. Title: Nouvelle generation de disperseurs/emulsionneurs.
AUTHOR: Schiff-Francois, A. ; Sturm, J.
JOURNAL: Chim. Mag., Issue: 142, Page(s): 38-40
ISSN: 0245940X
PUBLICATION DATE: 1996 (960000) LANGUAGE: French

...ABSTRACT: number of revolutions is variable up to 85 Hz. The emulsifier is made of polypropylene, **polycarbonate** or HD-polyethylene. Cleaning and **sterilization** are easy. Clearance volumes are reduced to a minimum. The emulsifier can be used for batch and in-line processes. (H.Schrod)
DESCRIPTORS: English ; dispersion ; emulsification ; mixing ; rotary mixer ; drop size ; batch process ; online instrumentation ; cleaning ; **sterilization** ; polypropylene ; **polycarbonate** ; polyethylene

31/3,K/9 (Item 7 from file: 315)
DIALOG(R)File 315:ChemEng & Biotec Abs

402255 CEABA Accession No.: 27-12-026679 DOCUMENT TYPE: Journal
Title: Factors affecting yields of α hormones of Phytophthora parasitica obtained by adsorption.
AUTHOR: Ko, W. H. ; Chern, L. L. ; Tang, C. S.
CORPORATE SOURCE: Univ. Hawaii Dep. Plant Pathology Hilo, Hi 96720 USA
JOURNAL: Can. J. Microbiol., Volume: 42, Issue: 2, Page(s): 172-176
CODEN: CJMIAZ ISSN: 00084166
PUBLICATION DATE: Feb 1996 (960200) LANGUAGE: English

...ABSTRACT: Both hormones α1 and α2 were adsorbed on a Millipore filter. Usage of **polycarbonate** membrane in the original method was replaced by **sterilization** of the filter with ethanol. Ethanol was the most effective in extracting both α hormones from the Millipore filter. A 1 min shaking of the hormone-loaded filter with 95% ethanol was sufficient to extract ca. 95% of hormones α1 and α2.

31/3,K/10 (Item 8 from file: 315)
DIALOG(R)File 315:ChemEng & Biotec Abs

311368 CEABA Accession No.: 24-03-003980 DOCUMENT TYPE: Journal
Title: The removal of bacteria from solutions by membrane filtration.
AUTHOR: Bobbitt, J. A.; Betts, R. P.
CORPORATE SOURCE: Campden Food Drink Res. Association Chipping Campden UK
JOURNAL: Journal of Microbiological Methods, Volume: 16, Issue: 3 , Page(s): 215-220
CODEN: JMIMDQ ISSN: 01677012
PUBLICATION DATE: Nov 1992 (921100) LANGUAGE: English

...ABSTRACT: were passed through a range of pore sizes (0.22-12.0 μm) of **polycarbonate** screen-type membranes and cellulose ester depth-type membranes. The numbers of viable microorganisms recovered ...

... the filtrate from each type of membrane at equialent stated pore size were very different. **Polycarbonate** screen membranes allowed cells to pass more freely through them and a very distinct threshold...

... more potential for the selective removal of bacteria from solution according to size whilst the **sterilization** of fluids would be better achieved using depth-type filters.

DESCRIPTORS: English; membrane filter; **polycarbonate**; membrane filtration; filtration, membrane; filtration optimization; bacteria; food analysis

31/3,K/11 (Item 1 from file: 285)
DIALOG(R)File 285:BioBusiness(R)

00940100
Investigations into the potential degradation of **polycarbonate** baby bottles during **sterilization** with consequent release of bisphenol A.
Mountfort K A; Kelly J; Jickells S M; Castle L
Ministry Agriculture Fisheries Food, CSL Food Sci. Lab., Norwich Research Park, Colney, Norwich NR4 7UQ, UK.
Food Additives and Contaminants Vol.14, No.6-7, p.737-740, 1997.

Investigations into the potential degradation of **polycarbonate** baby bottles during **sterilization** with consequent release of bisphenol A.

...ABSTRACT: of plastic baby feeding bottles were purchased and all were found to be made of **polycarbonate**. Taking a batch of one representative sample, the polymer was tested for stability and possible release of bisphenol A following domestic practice of **sterilization**. **Sterilization** was by alkaline hypochlorite, steam, or washing in an automatic dishwasher at 65 degree C with detergent. A total of 20 cycles of **sterilization** and subsequent food use were performed for each of the three procedures. Bisphenol A migration was in all cases not detectable in infant feed using a very sensitive method of liquid chromatography with fluorescence detection with a 0.03 mg/kg detection limit.

...DESCRIPTORS: **POLYCARBONATE**; ...

...**STERILIZATION**

31/3,K/12 (Item 2 from file: 285)
DIALOG(R)File 285:BioBusiness(R)

00923890
Culture materials affect ex vivo expansion of hematopoietic progenitor cells.
Laiuppa J A; McAdams T A; Papoutsakis E T; Miller W M
Dep. Chem. Engineering, Northwestern Univ., Evanston, IL 60208-3120, USA.
Journal of Biomedical Materials Research Vol.36, No.3, p.347-359, 1997.

...ABSTRACT: polystyrene were tissue culture polystyrene, Teflon perfluoroalkoxy, Teflon fluorinated ethylene propylene, cellulose acetate, titanium, new **polycarbonate**, and new polymethylpentene. MNC were less sensitive to the substrate materials than the primitive CD34...

...to be caused by protein adsorption and/or leaching of toxins. Factors such as cleaning, **sterilization**, and reuse significantly affected the performance of some materials as culture substrates. We also used PB CD34+ cell cultures to examine the biocompatibility of gas-permeable cell culture and blood storage bags and several types of tubing commonly used with

biomedical equipment. While many of the culture bag materials gave satisfactory results, all of the tubing materials severely inhibited total cell and CFU-GM expansion. Taken together, our results show that many materials approved for blood contact or considered biocompatible are not suitable for use with hematopoietic cells cultured in serum-free medium. As hematopoietic cultures are scaled up for a variety of clinical applications, it will be essential to carefully examine the biocompatibility of all materials involved.

31/3,K/13 (Item 3 from file: 285)
DIALOG(R)File 285:BioBusiness(R)

00642606
Evaluation of a series of tyrosine-derived polycarbonates as degradable biomaterials.
Ertel S I; Kohn J
Dep. Chem., Rutgers, State Univ. N.J., P.O. Box 939, Piscataway, NJ 08855, USA.
Journal of Biomedical Materials Research Vol.28, No.8, p.919-930, 1994.

...ABSTRACT: behavior and strength retention; the polymers with short pendent chains were more readily hydrolyzable. For **sterilization**, ethylene oxide treatment was less destructive, as judged by molecular weight retention, than gamma-irradiation...

...The cell response was influenced by the chemical structure of the polymer. The least hydrophobic **polycarbonate** (having a short ethyl ester pendent chain) was a more stimulating substrate for cell growth than the more hydrophobic polymers (carrying longer alkyl ester pendent chains).

31/3,K/14 (Item 4 from file: 285)
DIALOG(R)File 285:BioBusiness(R)

00444216
Polycarbonate resin composition for radiation **sterilization**: US PATENT-5118726. June 2, 1992.
Mizutani M; Nagai S; Masumoto M; Aso T
KANAGAWA, JAPAN.
Official Gazette of the United States Patent and Trademark Office Patents Vol.1139, No.1, June 2, p.412-413, 1992.
PATENT NUMBER: US 5118726 PATENT DATE: June 2, 1992 (19920602)
PATENT CLASSIFICATION CODE: 523136000

Polycarbonate resin composition for radiation **sterilization**: US PATENT-5118726. June 2, 1992.

31/3,K/15 (Item 5 from file: 285)
DIALOG(R)File 285:BioBusiness(R)

00320449
Mobay eyes medcare mart.
Anon
Chemical Marketing Reporter Vol.239, No.4, Jan. 28, p.5, 1991.

ABSTRACT: Mobay Corporation has developed radiation stabilized **polycarbonate** resins to be used in disposable critical care products, drug delivery systems and other health...

...will be marketed under the Makrolon product line and offer an alternative to ethylene oxide **sterilization** which releases chlorofluorocarbons.

...DESCRIPTORS: RADIATION STABILIZED **POLYCARBONATE** RESINS; MAKROLON PRODUCT LINE; NEW PRODUCTS; CHLOROFLUOROCARBONS; CFC

31/3,K/16 (Item 1 from file: 357)
DIALOG(R)File 357:Derwent Biotech Res.

0255997 DBR Accession Number: 2000-10487
Comparative assessment of chemical and gamma-irradiation procedures for implantable glucose enzyme electrodes - Aspergillus niger glucose-oxidase immobilization for sugar analysis
AUTHOR: Ahmed S; Rigby G P; Crump P; Vadgama P M
CORPORATE AFFILIATE: Hope-Hosp.Salford
CORPORATE SOURCE: Section of Clinical Biochemistry, Clinical Sciences Building, Hope Hospital, Salford M6 8HD, UK.
email:sahmed@fsl.ho.man.ac.uk
JOURNAL: Biosensors Bioelectron. (15, 3-4, 159-65) 2000
ISSN: 0956-5663 CODEN: BBIOE4
LANGUAGE: English

...ABSTRACT: crosslinked with glutaraldehyde and subsequently polyurethane (10, 16, 33 and 50% vol/vol) followed by **polycarbonate** urethane (2% wt/vol in dimethyl formamide). Different methods for sterilizing the enzyme electrode were...

...exposed electrodes exhibiting a 30% reduction in response, comparable to 10 min exposure to chemical **sterilization** . However, gamma-irradiation of 25 KGy was well tolerated and subsequent testing (following contamination with Streptococcus epidermidis and Staphylococcus aureus) proved device sterility with no culture growth after 7 days at 37 deg in brain heart infusion medium. (17 ref)
DESCRIPTORS: Aspergillus niger glucose-oxidase immobilization, implantable enzyme electrode, chem., gamma-irradiation **sterilization**, appl. glucose analysis fungus EC-1.1.3.4 biosensor (Vol.19, No.18)

31/3,K/17 (Item 2 from file: 357)
DIALOG(R)File 357:Derwent Biotech Res.

0129002 DBR Accession No.: 92-01494
A programmable micropropagation apparatus using cycled liquid medium - improved propagation; new plant tissue culture vessel with cycled liquid culture medium, semi-automation and **sterilization**
AUTHOR: Simonton W; +Robacker C; Krueger S
CORPORATE SOURCE: Department of Horticulture, Georgia Experiment Station, Griffin, GA 30223, USA.
JOURNAL: Plant Cell Tissue Organ Culture (27, 2, 211-18) 1991
CODEN: PTCEDJ

LANGUAGE: English

- improved propagation; new plant tissue culture vessel with cycled liquid culture medium, semi-automation and **sterilization**

ABSTRACT: **Polycarbonate** containers (Consolidated Plastics 51520AJ) (7 liters) were modified by the addition of a silicone gasket...

... and used as plant cell culture vessels. A plant support structure constructed of a machined **polycarbonate** frame and polypropylene perforated sheet was developed and attached to the inside of the container. To supply liquid media to the culture vessels, an apparatus was designed to allow cycling of the culture medium, thus exposing the plants to the medium intermittently rather than continuously. A computer (Matrix STDbus) was utilized to control the propagation apparatus, and was able to control the medium flow rate and level into individual vessels, cycling medium in and out of the vessels on an assigned schedule, filtering the medium over a 4-wk-growth cycle, and changing the medium within a growth cycle. A significant increase in shoot production in this apparatus was obtained using Amelanchier x grandiflora cultures. However, a smaller vessel with an easier sealing mechanism and a noninvasive liquid-level sensing and automated data acquisition would be beneficial. (21 ref)

DESCRIPTORS: ...x grandiflora, new plant tissue culture vessel apparatus providing cycled liquid culture medium, semi-automation, **sterilization**

31/3,K/18 (Item 3 from file: 357)
DIALOG(R)File 357:Derwent Biotech Res.

0108606 DBR Accession Number: 90-11297
Development of a semi-automated micropropagation system - propagation using large culture vessel with manipulation of gas and culture medium components (conference abstract)
AUTHOR: Robacker C; Simonton W; Farmer B; Krueger S
CORPORATE SOURCE: Department of Horticulture, Georgia Station, Griffin, GA 30223-1797, USA.
JOURNAL: In Vitro (26, 3, Pt.2, 74A) 1990
CODEN: ITCSAF
LANGUAGE: English

...ABSTRACT: the gas and culture medium components during the culture period. The system consists of clear, **polycarbonate** culture vessels containing a plant support platform of perforated sheet polypropylene, which are attached via silicone tubing to 10 l polypropylene carboys containing liquid culture medium. **Sterilization** is achieved through autoclaving. A computer controls cycling of the medium into and out of the culture vessels. This system was modified to include smaller vessels sealed with a silicone gasket and polysulfone clamps to reduce contamination and to ease manipulation. A non-invasive method involving IR emitter-detector pairs is used to monitor the culture medium level. A woody ornamental tree, Amelanchier x grandiflora 'Princess Diana' has been propagated successfully using this semi-automated system. (0 ref)

31/3,K/19 (Item 4 from file: 357)
DIALOG(R)File 357:Derwent Biotech Res.

0088233 DBR Accession No.: 89-06224 PATENT
Fermentor - with oxygen-enriched membrane
PATENT ASSIGNEE: Toray 1989
PATENT NUMBER: JP 1030576 PATENT DATE: 890201 WPI ACCESSION NO.: 89-079992 (8911)
PRIORITY APPLIC. NO.: JP 87187437 APPLIC. DATE: 870727
NATIONAL APPLIC. NO.: JP 87187437 APPLIC. DATE: 870727
LANGUAGE: Japanese

...ABSTRACT: against water vapor or heated water. The compressor and fermentor are connected to each other. **Sterilization** of the total apparatus is easily performed using heated water and water vapor. The membrane...

... coating of silane graft polymer. The heat resistant resin is polyethylene terephthalate, polybutylene terephthalate, FRP, **polycarbonate** , polysulfone, polypropylene, vinyl chloride polymer, fluorine resin, etc. (8pp)

...DESCRIPTORS: Radiation **sterilization**--Usage

15/3,K/2 (Item 2 from file: 148)
DIALOG(R)File 148:Gale Group Trade & Industry DB

04887933 SUPPLIER NUMBER: 09199754 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Plastics zero in on clarity, stability and cost goals. (Medical Plastics)
Miller, Bernie
Plastics World, v48, n13, p42(4)
Dec, 1990
ISSN: 0032-1273 LANGUAGE: ENGLISH RECORD TYPE: FULLTEXT
WORD COUNT: 3147 LINE COUNT: 00259

... variety of medical polymers is filling the prescription for properties retention and color stability after **sterilization**, as shown by the material developments of the past year
Medical polymers continue to proliferate...

...pouches for intravenous (IV) and other parental procedures, are not likely to abandon the polymer.
Sterilization a central issue
The most significant resin trend continues to be the shift away from ethylene oxide (ETO) to **gamma radiation** for sterilizing a wide variety of packaged, disposable items. Radiation-vulnerable polymers such as PVC...
...successfully modified to retain their properties after radiation, while most of the clear polymers, notably **polycarbonate** (PC), acrylics, and ABS now are available with additive systems to offset the color shift from radiation. Thermoplastic polyesters (notably PET) have excellent radiation stability.
Electron beam **sterilization**, while promising substantial reductions in cycle time and floor space, will not displace gamma any...

...scarcity of data on their effect on plastics will retard their growth.
Steam autoclaving, chemical **sterilization** and dry heat remain the standard methods for sterilizing nondisposable equipment and components. These applications...

...resin and other 23 Series resins can be used in applications involving ETO or steam **sterilization**.
Other recent Rexene offerings include a thermoforming grade and an impact-modified grade for thickwall...

...for forming instrument trays, suture kits and other disposable packaging and are said to resist **discoloration** and **embrittlement** up to 5 megarad **gamma sterilization**. It also accepts other **sterilization** methods. The PP resin has a notched Izod value of 2.5 ft-lb/in., a 150,000 psi flex modulus, and can be deep-drawn to 15-mil thickness. Deflection temperature at 66 psi load is 185 [degrees] F.
For thick-walled medical utensils such as basins and water pitchers, Rexene introduced 13R25A. The radiation-resistant, impact-modified random copolymer develops higher Gardner impact values than other PPs as well as high-density PE. Notched Izod and mechanical properties also are rated high compared to other medical grades of its type.
Making news at Himont is a new series of PPs capable of melt-phase thermoforming. Target applications for these resins--Pro-fax PF-613

homopolymer and Pro-fax SD impact copolymer--are medical disposable kits, trays and similar ...The as-yet unnamed Pro-fax resins, one of which is designed for 5 megarad **gamma sterilization**, are said to have haze levels in the 5% range, exceptionally good for PP. Labware...

...standard SAN counterpart. It's also better than the 1-2% haze level typical of **polycarbonate** and acrylic, Jeff Lenger, medical market manager, points out.

Another plus is lower melt stiffness...

...and tensile strength, however.

Sparkle's physical properties and heat resistance are virtually unaffected by **gamma-radiation** doses of up to 4 megarads, Monsanto's test indicates. Permanent color shift following from...

...color-change problems with another type of styrenic during a program to replace ETO with **gamma sterilization**.

Among the impact-modified acrylics, Cyro national sales manager Stephen Magaziner reports the use of...

...at Eastman Performance Plastics.

Key selling points are very high color and properties stability in **gamma radiation** (particularly the copolyesters), over 16 ft-lb/in. notched Izod impact, and excellent chemical resistance...

...1.6-2.4%, respectively. Current prices are $1.80/lb for Ektar DA polyester/**polycarbonate** alloy and $1.09 and $1.22/lb for Ektar DN copolyesters in truckload quantities...

...10 million female Luer locks to date in a 32-cavity mold using DN-003.

Polycarbonate improvements

Mobay's Makrolon Rx-2530 PC offers improved cosmetics because it undergoes about 50% less color shift after **gamma sterilization** compared to other medical-grade PCs. This means that lower concentrations of the blue-purple...

...the amount of color reversal expected in the treated product. "It's unlikely that the **polycarbonate** can be made to recover to SAN clarity," technical marketing manager Dr. Donald Folajtar acknowledges...

...believes its Durethan C-38F nylon 6 copolymer brings nylon into the picture for steam **sterilization**. The copolymer is proposed as a lamination for polyethylene film to improve puncture and tear resistance. Standard nylon 6 tends to flex crack after steam **sterilization**.

One of the latest refinements in GE Plastics' line of Lexan HP (healthcare product) PCs...

...including gamma.

More ABS choices

Dow has expanded its base in medical polymers beyond its **Calibre** 2000 series of PCs with the introduction of ABS medical grades. Intended applications for the Magnum 2600 series include molded components for blood collection, dialysis, intravenous therapy and other

...shift recovery from 5 megarad exposure and are now being checked out for electron-beam **sterilization**, according to medical market specialist D'Lane Wisner. Companion rigid grades are offered for ETO **sterilization**, too.

Also in the works at Goodrich is a gamma-stable PVC elastomer destined for...

...lower density combined with the ability to downgauge. These olefinic materials match PVC as an **oxygen** barrier. New grades have excellent moisture barrier, Horizon says. A recent application for these materials...

...polymer group, however, is much greater in medical and dental equipment subjected to repeated steam **sterilization**. For these applications the polymer choices narrow down to the sulfones and polyether imide.

Polysulfone historically has dominated steam-**sterilization** applications because of its excellent hydrolytic stability and price advantage over the alternatives. In institutions...

...study using morpholine-doped steam, trays molded from PEI showed little surface crazing after 650 **sterilization** cycles and were still usable after 1,500 cycles. Trays molded from polysulfone and polyether...

...is evaluating Apec HT, its high-temperature "copolycarbonate," as a packaging material for dry-heat **sterilization**. Because its glass transition temperature, 330 [degrees] F, is about 50 [degrees] higher than that of standard PCs, Apec HT will open the door for PCs in that **sterilization** process by sharply reducing the sterilizing time and energy costs, Mobay's Dr. Donald Folajtar notes.

PHOTO : Reusable **syringe** for administering dental liquids from single-use cartridges was redesigned from stainless steel handle and painted aluminum handle. The 20%-glass polyarylsulfone withstands steam/chemical **sterilization** that damaged paint and reduced fabrication costs.

PHOTO : Assess peakflow meter for asthmatics, made by...

...Products, is part of a growing wave of treatment kits and devices for home use. **Polycarbonate** gives unit the toughness to resist dropping and high clarity

15/3,K/3 (Item 3 from file: 148)
DIALOG(R)File 148:Gale Group Trade & Industry DB

04149609 SUPPLIER NUMBER: 08157661 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Plastics and composites. (materials selection; includes sidebars)
(Materials, manufacturing, and assembly volume.) (buyers guide)
Machine Design, v61, n23, p106(55)
Nov, 1989
DOCUMENT TYPE: buyers guide ISSN: 0024-9114 LANGUAGE: ENGLISH
RECORD TYPE: FULLTEXT
WORD COUNT: 36264 LINE COUNT: 03134

... on earth, plastics allow chemists to design materials using organic building blocks such as caron, **oxygen**, and hydrogen. Many changes have taken place since the first plastic -- Baklite -- was introduced in...

...known elments to create thousands of different plastics. These eight elements are carbon, hydrogen, nitrogen, **oxygen**, fluorine, silicon, sulfur, and chlorine.

Combining these atoms in various ways produces extremely large, complex molecules. Each atom has a limited capacity (energy bonds) for joining to other atoms, and every atom within a molecule must have all of its energy bonds satisfied if the compound is to be stable. Hydrogen, for example, can bond to only one other atom, while carbon or silicon must attach to four other atoms to satisfy its four energy bonds. Thus, H-H and

H-F are stable molecules, but C-H and Si-Cl are not.

As a further illustration, consider the simple organic compound, methane ([CH.sub.4]), the main component of natural gas. The carbon in methane is attached to four atoms of hydrogen, and each hydrogen is attached to the single atom of carbon. Thus, all energy bonds are satisfied, and the compund is stable. The molecular weight of methane, 16, is the total of the individual atomic weights of its constituent atoms.

Adding more carbon atoms in a chain and more hydrogen atoms to each new carbon crates heavier molecules. For example, ethane gas ([C.sub.2.H.sub.6]) is heavier than methane because it contains an additional carbon and two additional hydrogen atoms. Its molecular weight is 30. In a similar manner, molecular weight can be increased in increments of 14 (one carbon, two hydrogens) until the compound pentane ([C.sub.5.H.sub.12]) is reached. Pentane is too heavy to be a gas and is, instead, a liquid at room temperature. Further addition of [CH.sub.2] groups makes progressively heavier liquids until [C.sub.18.H.sub.38] is reached. This is a solid -- paraffin wax.

Thermoplastics: As molecules are made longer and become heavier, the paraffin wax becomes harder and tougher. At approximately [C.sub.100.H.sub.202], the material, with a molecular weight of 1,402, is tough enough to be useful as a plastic -- this is low-molecular-weight polyethylene, the simplest of the thermoplastics.

Continuing the addition of more [CH.sub.2] groups to the chain increases strength and toughness even more. The toughest polyethylene contains more than one-quarter million [CH.sub.2] groups and is called ultrahigh-molecular-weight (UHMW) polyethylene. In between are medium-molecular-weight polyethylene (1,000 to 5,000 carbons) and high-molecular-weight polyethylene (5,000 to 50,000 carbons).

Although the example of polymer chain growth shown in the table implies the addition of one [CH.sub.2] group at a time, in reality, a single [CH.sub.2] group cannot be added easily because it does not exist as a stable compound. Instead, groups of organic compounds, called monomers, are used.

The structure of these monomers seems to conflict with the rule that carbon must be attached to four other atoms in order to be stable. But like all rules, there are exceptions. In certain cases, a double bond, which is stable, can be formed between atoms. As illustrated in Fig. 1, ethylene monomer, [CH.sub.2] = [CH.sub.2], is made by removing (under heat and pressure) two hydrogens from ethane, [CH.sub.3--CH.sub.3]. A redistribution of electrons occur, and a doule bond is formed. The double bond plus the two single bonds thus atisfy the four energy bonds of the carbon atom, forming a stable monomer.

Then, starting with billion of molecules of monomer in areactor, heat and pressure are applied in the presence of catalysts, causing one of the monomer double bonds to rearrange into two "half bonds," one at each end. These half bonds combine with half bonds of other rearranged monomer molecules, forming stable "whole bonds" between them. As each monomer joins with others, the ...the strength of amorphous materials at higher temperatures.

Examples of amorphous thermoplastics are ABS, polystyrene, **polycarbonate**, polysulfone, and polyetherimide. Crystalline plastics include polyethylene, polypropylene, nylon, acetal, polyethersulfone, and polyetheretherketone.

Copolymer structures: Another method for altering molecular symmetry is to combine two different monomers in the polymerization reaction so that each polymer chain is composed partly of monomer A and partly of monomer B. A polymer made from two different monomers is called a copolymer; one made from three different monomers is called a terpolymer.

All long, repeating chains are polymers, regardless of how many

monomers are used. But when a polymer family includes copolymers, the term "homopolymer" is used to identify the single monomer type. An example is the acetal family; acetal resins are available both in homopolymer and copolymer types.

Final properties of a copolymer depend on the percentage of monomer A to monomer B, the properties of each, and on how they are arranged along the chain. As shown in Fig. 3, the arrangement may alternate equally between the two monomers, producing a symmetrical shape capable of a high degree of crystallization. Or the arrangement may be random, creating areas of high crystallinity separated by flexible, amorphous areas. Such a copolymer usually has good rigidity and impact strength.

Block copolymers have large areas of polymerized monomer A alternating with large areas of polymerized monomer B. In general, a block copolymer is similar to an alternating copolymer except that is has stronger crystalline areas and tougher amorphous areas. If both types of blocks are crystalline, or both amorphous, a wide variety of end products is possible, having characteristics ranging from hard, brittle plastics to soft, flexible elastomers.

A graft copolymer is made by attaching side groups of monomer B to a main chain of monomer A. A copolymer having a flexible polymer for the main ...and rollers, acrylic lenses, ABS (acrylonitrile-butadienestyrene) business-machine and appliance housings, polystyrene-foam cups, **polycarbonate** safety helmets and glazing sheet for bus windows, and polyphenylene sulfide chemical pumps and automotive under-hood components.

Thermosets: Thermoset plastics are made quite differently from thermoplastics. Polymerization (curing) of thermoset plastics in done in two stages, partly by the material supplier and partly by the molder. As illustrated in Fig. 4, plhenolic (a typical thermoset plastic) is first partially polymerized by reacting phenol with formaldehyde under heat and pressure. The reaction is stopped at the point where mostly linear chains have been formed. The linear chains still contain unreacted portions, which are capable of flowing under heat and pressure.

The final stage of polymerization is completed in the molding press, where the partially reacted phenolic is liquefied under pressure, producing a crosslinking reaction between molecular chains. Unlike a thermoplastic monomer, which has only two reactive ends for linear chain growth, a thermoset monomer must have three or more reactive ends so that its molecular chains crosslink in three dimensions. Rigid thermosets have short chains with many crosslinks; flexible thermosets have longer chains with fewer crosslinks.

After it has been molded, a thermoset plastic has virtually all of its molecules interconnected with strong, permanent, physical bonds, which are not heat reversible. Theoretically, the entire molded thermoset part could be a single giant molecule. In a sense, curing a thermoset is like cooking an egg. Once it is cooked, reheating does not cause remelting, so it cannot be remolded. But if a thermoset is heated too much or too long, the chains break and properties are degraded.

Phenolic, urea, and melamine thermoset platics are polymerized by a "condensation" reaction, wherein a by-product (water, for example) is created during the reaction in the mold. Such volatile by-products cause dimensional instability and low part strength unless they are removed during molding.

Other thermoset plastics, such as epoxy and polyester, cure by an "addition" reaction, resulting in no volatile by-products and fewer molding problems. Most addition-cured thermoset plastics are liquid at room temperature; the two ingredients can simply be mixed and poured into molds where they crosslink (cure) at room temperature into permanent form -- much like casting concrete. Molds are often heated, however, to speed the curing process.

In general, thermoset plastics, because of their tightly crosslinked structure, resist higher temperatures and provide greater dimensional stability than do most thermoplastics. Examples of thermoset plastic products include glass-reinforced-polyester boat hulls and circuit-breaker components, epoxy printed-circuit boards, and melamine dinnerware.

Alloys and blends: Yet another way to create more variations in plastics is alloying -- an effective and economical method to improve a weak property in a base resin. Plastic alloys, also called blends or polyblends, are usually designed to retain the best characteristics of each material. Properties that have been found to be most responsive to improvement are impact strength, heat-deflection temperature, flame retardance, chemical and weather resistance, and processibility. A study by Battelle reports that research on polymer blending generates about 1,000 patents per year.

Although no totally accepted definition exists, most engineers and chemists in the plastics industry agree that a plastic alloy is identified by most of these characteristics:

* The combination of polymers does not depend on chemical bonds; the mixture is entirely mechanical. Thus, copolymers (some acetals and polyolefins) and terpolymers are not alloys. Nor are epoxy compounds that copolymerize with hardeners that contribute to the properties of the cured resins.

* The mixture has a single melt-transition temperature.

* At least one property or characteristic of the base polymer is improved synergistically by the addition of the other polymer(s). The property may be physical or mechanical, or the improvement may be in processibility or cost. If synergistic improvement is not achieved, at least the best properties of all constituents are retained.

* Each minor component of a plastic alloy constitutes at least 5% of the mix. Many are nearer the 50:50 range. This "requirement" differs considerably from those involving metal alloys. There, only enough of an alloying element need be present to effect a change in a mechanical or physical property. The magnitude of such a change is not important.

IPNs: A new technology that combines incompatible polymers to form blends called interprenetrating polymers networks (IPNs) promises to provide cost/performance benefits not previously available in engineering plastics. Several companies are working on IPN development, but only a few have made developmental IPN materials available.

IPNs consist of an interwoven matrix of two polymers. A typical method for producing these alloys involves cross-linking one of the monomers in the presence of the other polymer. The need for chemical similarity between the two types of molecules is thus reduced because the crosslinking physically traps one phase within the other. The result is a structure composed of two different materials intertwined together, each retaining its own physical characteristics. The relationship is similar to that between small blood vessels and the surrounding tissue in the human body.

Patented IPN technology by Shell Chemical Co. is based on the capability of ...s resistance to burning is determined from ASTM D2863, which measures the minimum concentration of **oxygen** in an **oxygen** /nitrogen mixture that will support candle-like burning for 3 min or longer. Results are reported as a Limiting **Oxygen** Index (LOIs). Composites with LOIs over 28% are usually listed as 94V-0.

Smoke emission is measured in the air column above a burning specimen in a National Bureau of Standards smoke chamber. In the test, a specified area of plastic is exposed to heat under flaming conditions. Smoke measurements are reported as "specific optical density." This is a dimensionless value because it represents the optical density measured over unit path length within a chamber of unit volume produced from a test

specimen of unit surface area. The optical density measurement, [(D.sub.max)], is based on the attenuation of a light beam by smoke accumulating within the closed chamber during flaming combustion. (For a reference, the [D.sub.max] for red oak is 76.)

Smoke generated during combustion consists of suspended soot particles that are formed between the pyrolysis zone and the flame front. These particles are molecules of highly condensed ring structures that are most readily formed by aromatic polymers (SAN, SMA, and polyphenylene ether). Polymers having aliphatic carbon backbones, such as polypropylene and nylon, tend to generate less smoke, but this effect is offset in the FR compounds by the increase in smoke caused by halogenated flame-retardent additives. Resins of higher thermal stability (PC, PSF, PES, PEEK, and PPS produce the least smoke of the available UL94V-0 thermoplastics.

Experience needed: There is no simple procedure for selecting the best plastic for a new application. It must be done with direct experience and knowledge of the behavior of various plastics under the real-life conditions to be encountered by a particular part after it is molded.

Until this experience is acquired, a designer has little choice but to seek the advice of a reliable molder, materials manufacturer, or compounder. Even here, there is the danger that these sources may not be aware of the many compromises a company must make internally among production, engineering, purchasing, and marketing considerations to produce a product that will sell at a profit. Also, a molder might be inclined to recommend the material that works best in his equipment, rather than the best for the application. Thus, the successful design of plastic parts that have the optimum cost/performance characteristics require learning as much as possible about many different plastics and the peculiarities of their processing.

Designers used to take little interest in the molding of parts they designed. They sent the drawings to the molder in another department or another company and expected perfect parts to emerge. But design and processing have become so interrelated that this separation can no longer exist if products are to be consistently successful.

Molders can usually be relied upon to detect and correct visible problems or readily measured factors such as color, surface condition, and dimensions. However, less apparent property changes are another matter. These may not show up until the moldings are in service, unless extensive testing and quality control are used. Such properties as impact strength, toughness, and chemical resistance can be diminished by improper control of processing parameters. Close cooperation between designers and molders can eliminate disappointment and help ensure successful products.

After candidate materials are selected, the design should be tested under real-life conditions involving the temperatures, loading, and environment of the anticipated service. Ideally, the test part should be molded in the shape and from the material to be used in production. In the beginning, this is costly and time consuming, but as experience is acquired, accelerated tests can be developed on simpler shapes; testing will then be more economical but just as reliable.

Understanding the molding process that will produce the part is also necessary. The process directly affects material choice, shape, tolerances, and properties of the part. For example, a container or housing can be made by injection molding, blow molding, thermoforming, or rotational molding. But each process requires a markedly different design, would use a different grade of plastic or a different plastic entirely, and would produce a component with significantly different properties.

All molding processes alter the published data-sheet properties, reducing most strengths and often creating areas of stress concentrations. But each process may create stresses in different areas. Sometimes, processing conditions are so severe that there is no choice but to redesign

the shape and change to a different plastic. Unfortunately, reliable data on molded strength properties may never be available because of the basic nature of plastics. Their characteristics are partly those of solids and partly those of viscous liquids, preventing the use of classical Hookean engineering formulas for ...nylon, acetal, and polyethylene. The variations are usually smaller in amorphous materials such as ABS, **polycarbonate** , and polystyrene, but even minor differences can be critical in some applications.

Molding, rther than machining, of prototypes generally provides a better approximation of a production part, but here too, a number of differences in conditions can cause misleading results. For example, if the prototype mold is made from epoxy resin, the molded part will cool at a much slower rate than it would in a production (steel) mold. And cooling rate can affect tensile and impact strength as well as heat and chemical resistance, elongation, and stiffness -- particularly in crystalline plastics.

Making prototypes in an aluminum mold improves their similarity to production parts, but this method also has drawbacks. Here, because of the high thermal conductivity of aluminum, faster cooling is the problem that alters properties from what they would be in a part made in a steel mold. Also, there is difficulty in getting the resin to flow into a mold that cools rapidly. This problem can be offset by higher injection pressure, but the greater density that results causes other variations.

The closet duplication of a production part is produced by injection-molding prototype parts in steel molds. A relatively soft steel can be used for prototypes, so that machining is not difficult. But even here, because certain shortcuts are usually made (in polishing surfaces or in simplifying cooling passages, for example), the quality and accuracy of the resultant moldings are something less than what would be expected in production moldings. Nevertheless, steel prototype molds produce parts that most nearly duplicate production parts. Although this is the most expensive prototyping method, it may be the most economical in that it provides the surest way to avoid expensive changes in production molds.

Computer-aided design: In order to reduce the number of prototypes required, designers are turning to finite-element analysis. FEA programs allow parts design and structural analysis before tooling is cut. Related software, such as moldfilling analysis and warpage programs, help to eliminate processing problems before they start.

Many of these programs depend on materials databases that organize various properties into a manageable format. Integrating FEA and molding programs with a database often optimizes the use of capital-intensive CAD/CAM equipment. Databases also enable users to conduct a fast and efficient materials search.

Thermoplastic composites

No longer is product design constrained to the property limits and performance characteristics of unmodified grades of resins. Thermoplastics that are reinforced with high-strength, high-modulus fibers provide dramatic increases in strength and stiffness, toughness, or dimensional stability. The performance gain of these composites usually more than compensates for their higher cost. Processing usually involves the same methods used for unreinforced resins.

Glass, mineral fibers: Glass fibers used in reinforced compounds are high-strength, textile-type fibers, coated with a binder and coupling agent to improve compatibility with the resin and a lubricant to minimize abrasion between filaments. Similar systems are used with mineral reinforcement. Glass-reinforced thermoplastics are usually supplied as ready-to-mold compounds. Molded products may contain as little as 5% and as much as 60% glass by weight. Pultruded shapes (usually using a polyester matrix) sometimes have higher glass contents. Most molding compounds, for

bst cost/performance ratios, contain 20 to 40% glass.

Practically all thermoplastic resins are available in glass-reinforced compounds. Those used in largest volumes are nylon, polypropylene, polystyrene, ABS, and SAN, probably because most experience with reinforced thermoplastics has been based on these resins. The higher performance resins -- PES, PEI, PPS, PEEK, and PEK, for example -- are alsa available in glass-fiber-reinforced composites, and some with carbon or aramid fibers as well.

Glass-fiber reinforcement improves most mechanical properties of plastics by a factor of two or more. Tensile strength of nylon, for example, can be increased from about 10,000 psi to over 30,000 psi, and deflection temperature to almost 500[degrees]F, from 170[degrees]F. A 40% glass-fortified acetal has a flexural modulus of 1.8 X [10.sup.6] psi (up from about 0....warpage characteristics. Polypropylene applications include automotive air-cleaner housings and dishwasher tubs and inner doors. **Polycarbonate** is used in housings for water meters and power tools. Polyester applications include motor components -- brush holders and fans -- high-voltage enclosures, TV tuner gears, electrical connectors, and automobile exterior panels. Camper tops, pallets, and hand luggage are typical applications of reinforced HD polyethylene.

Newest products in glass-reinforced compounds are the long-fiber materials. These compounds, available principally in a nylon 6/6 base resin, are produced by a pultrusion method. The injection-moldable pellets thus contain fully wetted fibers equal in length to the pellet -- typically 0.400 in. This compares to 0.030 to 0.060-in. fiber lengths in conventional, short-fiber products. In fiber loads of 50% by weight, mechanical properties are improved dramatically over those of the short-fiber compounds. Long-fiber-reinforced compounds are available in the U.S. from ICI Advanced Materials, Polymer Composites Inc., and Dexter Composites.

Continuous-fiber glass-reinforced polypropylene is available in sheet form, for stamping or hot-flow forming of large, th in-wall parts such as automotive front-end retainer panels, oilpans, fender liners, upper grille panels, and station-wagon load floors, and for lawn-mower shrouds, luggage, and housings and guards for farm equipment and snowmobiles. The product is marketed by Azdel Inc. The company also markets a glass-reinforced PET polyester sheet product and plans to add sheet materials based on other resin matrices.

Another new composite form is a sheet material in various thermoplastic matrix resins developed by Du Pont. Reinforcement is unidirectional but discontinuous glass, carbon, or aramid fibers.

Carbon fibers: Mostly developmental until a few years ago, carbon-fiber-reinforced compounds are now available in a number of thermoplastics, including nylon 6/6, polysulfone, polyester, polyphenylene sulfide, polyetherimide, polyetheretherketone, and ETFE and PFA fluorocarbons.

The carbon-fiber-reinforced materials, at two to four times the cost of comparable glass-reinforced thermoplastics, offer the ultimate in tensile strength (to 35,000 psi), stiffness, and other mechanical properties. Compared to the glass-reinforced materials these compounds (10 to 40% carbon) have a lower coefficient of expansion and mold shrinkage, and improved resistance to creep and wear. Strength-to-weight ratios are also higher.

Carbon-fiber reinforcement also makes plastic compounds partially conductive. In compounds containing small amounts of carbon, this characteristic is useful for applications where static charges cannot be tolerated. Compounds containing higher percentages of carbon can be used for applications such as business-machine housings to shield the equipment from electromagnetic interference (EMI). Attenuation of electromagnetic

radiation in carbon-fiber-reinforced nylon, for example, has been reported to be 36 to 40 dB in the frequency range from 50 kHz to 1 GHz.

Commercially available structural-carbon fibers are derived either from polyacrylonitrile (PAN) fibers or a special petroleum pitch. PAN-derived fibers have been available for several years and, for several of the lower modulus varieties, large databases have been developed through their use in aerospace programs. These fibers are generally selected for their high strength and efficient property translation into the composite.

The pitch-based fibers are newer and, while they are not as strong as the low-modulus PAN fibers, the ease with which they are processed into high-modulus components makes them attractive for stiffness-critical and thermally sensitive applications.

Pultrusion technology first provided long-glass fiber-reinforced composites with high-performance capabilities. Following close on the heels of this development are new long-carbon fiber-reinforced composites with even higher properties. Specifically, flexural and tensile moduli are the highest ever measured in discontinuous fiber-reinforced thermoplastic composites.

High stiffness-to-weight ratios and greater wear resistance allow these composites to compete against many metals. In addition, long-carbon composites are excellent candidates for applications requiring electrostatic dissipation and electromagnetic interference (EMI) shielding. Tests on some of the new composites have produced surprisingly high (60 dB and above) electromagnetic radiation attenuation values.

Aramid fibers: It would seem that aramid fibers, with greater specific strengths than steel or aluminum, would be an ideal reinforcement for thermoplastic resins. However, chopped aramid fibers do not compound as well as the conventional glass or carbon-fiber reinforcements. Proprietary sizing systems aid in wetting of the fiber, but extensive fiber damage results in properties for the composite that are less than spectacular.

On the plus side, aramid-fiber-reinforced composites have low ...The lubricants also allow the use of poor wearing, but high accuracy materials, such as **polycarbonate**, in gear or bearing applications. Lubricants can be used by themselves or in conjunction with glass or carbon-fiber reinforcements.

Polytetrafluoroethylene and silicone fluids; glass, aramid, and carbon fibers; and graphite powder are the primary reinforcements and lubricants used in internally lubricated composites. The composites are based on engineering resins for injection-molded wear and structural parts.

Polytetrafluoroethylene (PTFE) lubricants dispersed into a thermoplastic base resin greatly improve surface-wear characteristics. Molecular weight and particle size of the PTFE lubricant are designed to provide optimum improvements in wear, friction, and PV values for selected resin systems. PTFE has the lowest coefficient of friction (0.02) of any known internal lubricant. Its static coefficient of friction is lower than its dynamic coefficient, which accounts for the slip/stick properties associated with PTFE/metal sliding action. During the initial break-in period, the PTFE particles embedded in the thermoplastic matrix shear to form a high-lubricity film over the mating surface. The PTFE cushions asperities from shock and minimizes fatigue failure.

Silicone fluids are chosen for their ability to perform as boundary lubricants and for partial compatibility with a particular base resin. The silicone is sufficiently compatible with the base resin to form an alloy, yet incompatible enough to cause migration to the surface of the compound. The silicone moves to the surface of a molded or extruded part by two mechanisms: diffusion by random molecular movement, and exclusion from the matrix (migration) because of its limited compatibility. The result of the migratory action is a continuous generation of a silicone film, which serves as a boundary, or mixed-film lubricant.

Glass fibers improve both short-term and long-term mechanical properties of a resin. The fibers also improve creep resistance, thermal conductivity, and heat-deflection temperature as well as the tribological properties of the base resin. The degree of improvement depends on the efficiency of the sizing system that bonds the resin to the fibers. Glass beads and unsized milled-glass fibers, on the other hand, increase the wear factor of the mating surface and the coefficient of friction.

Glass fibers are frequently used in combination with silicone and PTFE lubricants which offset the negative wear effects that the glass fibers have on surface characteristics. The use of silicone only, in conjunction with glass fibers, is not recommended, however. PTFE provides far ...aqueous environments.

Reinforced and/or internally lubricated compounds are used in a variety of applications. **Polycarbonate**-based composites are used for gear and bearing surfaces where accuracy is important and chemical resistance is not a severe problem, such as in cameras and office equipment. Acetal and PPS-based compounds have found wide acceptance in hostile environments such as gasoline metering and pumping devices. Nylon composites are often chosen for certain harsh environments because of their excellent chemical resistance.

Thermoset composites

Ever since materials producers and compounders realized that material properties are improved significantly by the addition of a fiber or other reinforcing material, the field of composites, differentiating them from the glass/polyester composites that were emerging commercially in the 1950s. The "advanced" term has come to denote, to most engineers, a resin-matrix material reinforced with high-strength, high-modulus fibers of glass, carbon, aramid, or even boron, and usually laid up in layers to form an engineered component. More specifically, the term has come to apply principlally to epoxy-resin-matrix materials reinforced with oriented, continuous fibers of carbon or of a combination of carbon and glass fibers, laid up in multilayer fashion to form extremely rigid, strong structures.

Resin systems: More than 95% of thermoset composite parts are based on polyester and epoxy resins; of the two, polyester systems predominate in volume by far. Other thermoset resins used in reinforced form are phenolics, silicones, and polyimides.

Polyestes can be molded by any process used for thermosetting resins. They can be cured at room temperature and atmospheric pressure, or at temperatures to 350[degrees]F and under higher pressure. These resins offer a balance of low cost and ease of handling, along with good mechanical, electrical, and chemical properties, and dimensional stability.

Polyesters can be compounded to be flexible and resilient, or hard and brittle, and to resist chemicals and weather. Halogenated (chlorinated or brominated) compounds are available for increased fire retardance. Low-profile (smoother surface) polyester compounds are made by adding thermoplastic resins to the compound.

Polyesters are also available in ready-to-mold resin/reinforcement forms -- bulk-molding compound (BMC), and sheet-molding compound (SMC). Bulk-molding compound is a premixed material containing resin, filler, glass fibers, and various additives. It is supplied in a dough-like, bulk form and as extruded rope.

Sheet-molding compound consists of resin, glass-fiber reinforcement, filler, and additivies, processed in a continuous sheet form. Three types of SMC compounds are designated by Owens-Corning Fiberglas Corp., as random (SMC-R), directional (SMC-D), and continuous fiber (SMC-C). SMC-R, the oldest and most versatile form, incorporates short-glass fibers (usually about 1 in. long) in a random fashion. Complex parts with bosses and ribs are easily molded from SMC-R because it flows readily in a mold. SMC-C contains continuous glass fibers oriented in one direction, and SMC-D, long

fibers (8 to 12 in. long), also oriented in one direction.

Moldings using SMC-C and SMC-D have significantly higher unidirectional strength but are limited to relatively simple shapes because the long-glass fiber cannot stretch to conform to a shape. These two types of SMC are usually, but not always, used in combinations are available that contain a total of as much as 65% glass by weight. These materials are used for structural, load-bearing components.

High-glass-content sheet-molding compounds are also produced by PPG Industries, designated as XMC. These compounds contain up to 80% glass (or glass/carbon mixtures) as continuous fibers in an X pattern.

Epoxies are low-molecular-weight, syrup-like liquids that are cured with hardeners to crosslinked thermoset structures that are hard and tough. Because the hardeners or ...and ABS. Also available in formulations for foam molding are engineering thermoplastics such as nylon, **polycarbonate**, modified polyphenylene ether, polyester, acrylic-styrene-acrylonitrile, polysulfone and thermoplastic elastomers and alloys. Some resins are also available in glass-reinforced formulations.

Applications for structural-foam parts molded from the enginering resins extend beyond the wood-replacement products. They include satellite dishes, business-machine and computer housings and panels, processing tanks and housings, material-handling pallets and totes, underground utility boxes, and automotive components replacing die castings and glass-reinforced injection-molded components.

Engineering films

Specific properties that separate engineering films from their commodity counterparts include greater tensile and impact strength; improved moisture and gas barrier characteristics; good heat resistance and weather-ability; better bonding and lamination; and improved electrical ratings. One or more of these properties can be obtained by choosing from a number of different polymer films.

Several melt-processible engineering thermoplastic films such as oriented polyester, oriented nylon, and unoriented nylon, exhibit high strength especially at high temperatures. In addition, they provide toughness at low temperatures, stiffnes and abrasion resistance, and good chemical resistance. Polyester film is made from the PET polymer, principally by Du Pont (Mylar) and ICI (Melinex). The m onomer is polymerized, extruded, cast into a web, and biaxially oriented, forming a drawn polyester film.

Oriented polypropylene, a ...thermoplastic with low speciic gravity, has excellent resistance, relatively high melting point, and good strength. **Polycarbonate** film is specified for its toughness, clarity, and high heat-deflection temperature.

Polyimides, both thermoplastis...

...treatments, film is placed in a reaction chamber. After evacuation, the chamber is charged with **oxygen**, argon, helium, or nitrogen while a radio-frequency field ionizes the gas. A resultant glow...

...some ABS grades with other resins produce special properties. For example, ABS is alloyed with **polycarbonate** to provide a better balance of heat resistance and impact properties at an intermediate cost. Deflection temperature is improved by the **polycarbonate**; molding ease, by the ABS. Other ABS resins are used to modify rigid PVC for use in pipe, sheeting, and molded parts. Reinforced grades containing glass fibers, to 40%, are also available.

Related to ABS is SAN, a copolymer of styrene and acrylonitrile (no butadiene) that is hard, rigid, transparent, and characterized by excellent chemical resistance, dimensional stability, and ease of processing. SAN resins are usually processed by injection molding, but extrusion,

injection-blow molding, and compression molding are also used. They can also be thermoformed, provided that no postmold ...containing high concentration of hypochlorite ions. Solutions of 10% ammonium hydroxide and 10% sodium chloride **discolor** samples in prolonged immersion, but physical and mechanical properties are not significantly changed. Most organic reagents tested have no effect, nor do mineral oil, motor oil, or brake fluids. Resistance to strong alkalies is exceptionally good; specimens immersed in boiling 50% sodium hydroxide solution and other strong bases for many months show no property changes.

Strength of acetal copolymer is only slightly reduced after aging for one year in air at 240 [degrees] F. Impact strength holds constant for the first six months, and falls off about one-third during the next six-month period. Aging in air at 180 [degrees] F for two years has little or no effect on properties, and immersion for one year in 180 [degrees] F water leaves most properties virtually unchanged. Samples tested in boiling water retain nearly original tensile strength after nine months.

Applications: Industrial and automotive applications of Celcon acetal copolymer include gears, cams, bushings, clips, lugs, door handles, window cranks, housings, and seat-belt components. Plumbing products such as valves, valve stems, pumps, faucets, and impellers utilize the lubricity and corrosion and hot-water resistance of the copolymer. Mechanical components that require dimensional stability, such as watch gears, conveyor links, aerosols, and mechanical pen and pencil parts, are others uses. Applications for the FDA-approved grades include milk pumps, coffee spigots, filter housings, and food conveyors. Parts that require greater load-bearing stability at elevated temperatures, such as cams, gears, TV tuner arms and automotive under-hood components are molded from glass-fiber-reinforced grades.

Acrylic

Acrylic thermoplastics are known for their crystal clarity and outstanding weatherability. They are available in cast sheet, rod, and tube; extruded sheet and film; and compounds for injection molding and extrusion.

Cell-cast sheet is produced in several sizes and thicknesses. The largest sheets available are 120 X 144 in., in thicknesses from 0.030 to 4.25 in. Continuous cast ...the conventional acrylics.

Properties: Acrylic plastics transmit and control light, resist weather, are stable against **discoloration**, and have superior dimensional stability and an excellent combination of structural and thermal properties. Clear...

...These materials withstand exposure to light from fluorescent lamps without darkening or deteriorating. They ultimately **discolor**, howeveR, when exposed to high-intensity UV light below 265 nm. Special formulations resit UV emission from light sources such as mercury-vapor and sodium-vapor lamps.

Applications: Cast acrylic sheet is used in aircraft, boat, mass transit, architectural, and protective glazing; internally illuminated outdoor signs, lighting diffusers, and skylights; and product prototypes and demonstration models. Special ultraviolet-absorbing grades are used for document preservation in museum and for various photographic applications.

Acrylic film is used as a laminated protective surface on ABS, PVC, or other plastic sheet that is thermoformed into parts requiring resistance to outdoor weathering. Examples include motorcycle shrouds, recreational-vehicle panels, residential siding, and transformer housings.

Acrylic moldings are used for light-control lenses in lighting fixtures, camera lenses, vending-machine parts, and appliance panels, knobs, and housings. Automotive application include lenses for tailings and parking lights, instrument panels, nameplates, medallions, and dials. A modified molding compound contains an impact modifier to increase

toughness. Parts molded from these durable transparent materials include automotive dials, housewares, piano keys, medical instruments, and toys.

Specially formulated acrylic sheets is available for deeply formed components such as tub-shower units, which are subsequently backed with glass-fiber-reinforced polyester. Chemical resistance of this sheet is superior to that of conventional sheet.

Sheet extruded from the high-impact molding grade is used for signs, thermoformed products, toys, and glass-fiber-polyester-backed components such as camper tops, furniture, and recreational-vehicle bodies.

Alkyd

Alkyd molding compounds are based on unsaturated polyester-type resins, which are combined with crosslinking monomers, catalysts, reinforcements, lubricants, and fillers. The formulations are similar to those of thermosetting polyesters but with lower amounts of monomers.

Alkyds are part of the group of materials that includes bulk-molding compounds (BMCs) and sheet-molding compounds (SMCs). They are processed by compression, transfer, or injection molding. Fast molding cycles at low pressure make alkyds easier to mold than many other thermosets.

Alkyds are furnished in granular compounds, extruded ropes or logs, bulk-molding compound, flake, and putty-like sheets. Except for the putty grades, which may be used for encapsulation, these compounds contain fibrous reinforcement. Generally, the fiber reinforcement in rope and logs is longer than that in granular compounds and shorther than that in flake compound. Thus, strength of these materials is between those of granular and flake compounds. Because the fillers are opaque and the resins are amber, translucent colors are not possible. Opaque, light shades can be produced in most colors, however.

Properties: Low-moisture absorption and excellent dimensional stability and electrical properties are the outstanding characteritics of most alkyd ...materials are also characterized by excellent dimensional stability and resistance to moisture, chemicals, and liquid **oxygen**. They withstand strong and weak acids, alkalies, and organic solvents, even at elevated temperatures.

Allyl moldings have low mold shrinkage and postmold shrinkage -- attributed to their nearly complete addition reaction in the mold -- and have excellent stability under prolonged or cyclic heat exposure. Advantages of allyl systems over polyester are freedom from styrene odor, low toxicity, low-evaporation losses during evacuation cycles, no subsequent oozing or bleed-out, and long-term retention of electrical-insulation characteristics.

Applications: Diallyl phthalate monomer is used as a nonvolatile cross-linker in polyester compounds to improve properties and handling characteristics. Deflection temperature is raised to 400[degrees]F or higher, dimensional stability and electrical properties are upgraded, and flexural properties are retained for long periods at elevated temperatures. DAP is also used in combination with polyester resin systems for low-pressure decorative laminates. Allylic resins in powder and liquid form are used for coatings and for impregnating materials.

Allyl prepolymers are particularly suited for critical electronic components that serve in severe environmental conditions. Chemical inertness qualifies the resins for molded pump impellers and other chemical-processing equipment. Their ability to withstand steam environments permits uses in sterilizing and hot-water equipment. Because of their excellent flow characteristics, diallyl-phthalate compounds are used for parts requiring extreme dimensional accuracy. Modified resin systems are used for encapsulation of electronic devices such as semiconductors and as sealants for metal castings.

A major application area for allyl compounds is electrical connectors used in communications, computer, andaerospace systems. The high thermal

resistance of these materials permits their use in vapor-phase soldering operations. Uses for prepolymers include arc-track-resistant compounds for switchgear and TV components. Other representative uses are insulators, encapsulating shells, potentiometer components, circuit boards, and housings.

Allyl-based prepregs are used to make lightweight, intricate parts such as radomes, printed-circuit boards, tubing, ducting, and aircraft parts. Another use is in copper-clad laminates for high-performance printed-circuit boards.

Amino

Melamine and urea are the principal commercial thermosetting polymers called aminos. The amino resins are formed by an addition reaction of formaldehyde and compounds containing [NH.sub.2] amino groups. They are supplied as liquid or dry resins and filled molding compounds. Applying heat in the presence of a catalyst converts the materials into strong, hard products. Aminos are used as molding compounds, laminating resins, wood adhesives, coatings, wet-strength paper resins, and textile-treating resins.

The base resin used in urea and melamine molding compounds is water-white and transparent. Translucent and opaque colors are produced by adding pigments and opacifying agents. Cellulose fibers improve strength and dimensional stability and reduce light transmission.

Properties: Moldings made from amino compounds are hard, rigid, abrasion resistant, and have high resistance to deformation under load. They do not impart taste or odor to foods, and they have excellent electrical insulation characteristics. Melamines are superior to ureas in resistance to acids, alkalies, heat, boiling water, and for applications involving wet/dry cycling.

Urea and some melamime molding compounds have flammability ratings of 94V-0. Melamines containing alpha cellulose, mineral, or ...corrosive liquids (diaphragms, valves, sight glasses); seals, gaskets, Orings, valve seats, and packings for liquid-**oxygen** and hydrogen equipment; and flexible circuit laminations, wire insulation, jacketed cable, coil bobbins, and other electrical components. CTFE materials are FDA-approved for use in food-handling equipment. Thin, optically clear CTFE moldings are used for infrared windows in missiles, radome covers, oil-reservoir covers, and gage faces.

PVDF: Polyvinylidene fluoride, the toughest of the fluoroplastic resins, is available as pellets for extrusion and molding and as powders and dispersions for corrosion-resistant coatings. This high-molecular-weight homopolymer has excellent resistance to stress fatigue, abrasion, and to cold flow. Although insulating properties and chemical inertness of PVDF are not as good as those of the fully fluorinated polymers. PTFE and FEP, the balance ...is not recommended for use in contact with ketones, esters, amines, and some organic acids. **Oxygen** index is 44.

Although electrical properties of PVDF are not as good as those of...

...at 264 psi). Hardness of ETFE is Rockwell R50; that of ECTFE is R93.

Limiting **Oxygen** Index of ETFE is 31; that of EXTFE is 60. (LOIs of PTFE, FEP, andthe polymers are high-temperature steam, concentrated sulfuric acid, and boiling caustic materials.

Oxygen index of LCP resins ranges from 35 to 50%. When exposed to open flame, the material forms an intumescent char that prevents dripping and results in extremely low generation of smoke containing no toxic by-products. The resin has UL94V-0 and 5V flammability ratings at 1/16 in. and an NBS smoke-chamber rating [(NBS-D.sup.s.-4)] of 3 to 5. Compounds are unaffected by high doses of ionizing or cobalt 60 radiation (up to 10 billion rads), withstand high levels of ultraviolet radiation,

and are transparent to microwaves and other radiation of similar wavelength.

Easy processibility of the resins is attributed to its liquid-crystal molecular structure, which provies high melt flow and fast setup in molded parts. However, molded parts are highly anisotropic, and knit lines are much weaker than other areas. Properties are not affected by minor variations in processing conditions, and no postcuring i required.

Applications: Metal and ceramic replacement in applications that require resistance to high temperature, chemicals, mechanical stress, and creep is where LCP resins are expected to be used. Typical parts include electrical-electronic components such as connectors, sockets, and pin-grid arrays exposed to high-temperature manufacturing or service conditions; automotive and aerospace parts requiring high-temperature resistance and flame retardance; and chemical-process components -- for example, mass-transfer tower packing elements -- requiring resistance to aggressive substances at high temperatures.

Nylon

Nylons (polyamides), the first of the thermoplastic engineering resins, were developed originally as high-strength textile fibers. These crystaline plastics are available in compositions for molding and extruding, for solution and fluidized-bed coatings, and for casting.

Nylon 6/6 is the most widely used of the nylon plastics. Other general types are nylon 6/10 and nylon 6/12. These are higher-priced materials, used where greater dimensional stability is required. Filled and reinforced compounds of most types are also available.

The second most widely used of the nylon family is nylon 6. The 6 and 6/6 polymers account for 95% of U.S. nylon consumption. Properties of nylon 6 are similar to those of 6/6, but it absorbs moisture more rapidly and its melting point is 70[degrees]F lower. Also, the lower processing temperature and the less crystalline nature of nylon 6 result in slightly lower mold shrinkage.

Nylons 11 and 12 have better dimensional stability and electrical properties than the other nylons because they absorb less moisture. These types, which are more expensive than the others, are available compounded with plasticizers to increase flexibility and ductility.

The development of nylon toughening technology, involving dispersed separate phases of an olefinic or elastomeric toughener chemically bonded to the nylon matrix, has resulted in the availability of supertough resins. Notched Izod impact values of these materials are over 15 fr-lb/in., and they fail in a ductile manner. As extensions of this technology, various highly flexible toughened extrusion resins are also available for applications such as refrigeration hoses.

Other important types of nylon are the castable resins. These are liquid monomers of nylon 6 that polymerize and become solid at atmospheric pressure. Complex parts several inches thick and weighing hundreds of pounds can be cast. Particularly important innovations have been various flame-retarded (UL94V-0) formulations in reinforced, unreinforced, and toughened resins for electrical/electronic applications. Relatively new in the nylon family are transparent molding grades -- amorphous polyamides that offer better chemical resistance than other transparent thermoplastic.

Properties: Property comparisons among commercial grades of nylons vary widely because so many formulations are available. In general, however, nylons have excellent fatigue resistance, low coefficient of friction, good toughness (depending on degree of crystallinity), and they resist a wide spectrum of fuels, oils, and chemicals. They are inert to biological attack, and have adequate electrical properties for most voltages and frequencies.

The crystalline structure of nylons, which can be controlled to so degree in processing, affects stiffness, strength, and heat resistance. Low

crystallinity imparts greater toughness, elongation, and impact resistance, but at the sacrifice of tensile strength and stiffness.

Nylon 6/6 has the lower permeability of the nylons by gasoline, mineral oil, and fluocarbon refrigerants. The 6/10 and 6/12 types are used where lower moisture absorption (and better dimensional stability) are needed.

All nylons absorb moisture if it is present in the service environment. Moisture content decreases strength and stiffness, and increases elongation and impact resistance. Type 6/6 nylon usually reaches equilibrium of approximately 2.5% moisture at 50% relative humidity. Equilibrium moisture at 50% RH in nylon 6 is slightly higher. In general, dimensions increase by approximately 0.2 to 0.3% for each 1% of absorbed moisture. However, dimensional changes caused by moisture absorption can be compensated for by moisture conditioning prior to putting parts into service. Foundations such as 6/12, 11, and 12, are considerably less sensitive to moisture than the others.

Nylons that have not been compounded with a UV stabilizer are sensitive to ultraviolet light and should not be used for extended outdoor service. Carbon-black is the most effective of the UV stabilizers. These additives also increase tensile strength and hardness and decrease ductility and toughness slightly.

Nylons have good resistance to creep and cold flow compared to many less rigid thermoplastics. Usually, creep can be accurately calculated by using apparent-modulus values. Nylons have outstanding resistance to repeated impact. They can withstand a major fraction of a breaking blow almost indefinitely.

Applications: The largest user of nylon resins is the automotive industry. Good mechanical properties and resistance to heat and fuels make these materials suitable for mechanical and electrical hardware and under-hood components. Examples are timing sprockets, speedometer gears, cooling fans, wire connectors, and windshield-wiper parts. Other automotive uses are door-latch hardware and, in reinforced compounds, molded fender extensions, steering-column-lock housings, and brake-fluid reservoirs.

Bearings are another major use of molded and extruded nylon ...is rated 94V-0 at thicknesses as low as 0.008 in. and has an **oxygen** index of 45%. Reinforced grades have surpassed FAA requirements for flammability, smoke density, and toxic...

...good; tensile strength drops only about 5% after exposure to [10.sup.9] rads of **gamma radiation**. Chemical resistance is good, the resin being virtually unaffected by aliphatic and aromatic hydrocarbons, halogenated...

...The block and cylinder heads are made from a proprietary resin matrix/carbon-fiber composite.

Polycarbonate

Polycarbonates are amorphous engineering thermoplastics that offer exceptional toughness over a wide temperature range. The resins are produced in the U.S. by Dow Chemical Co. (**Calibre**), General Electric Co. (Lexan), and Mobay Chemical Corp. (Makrolon). The natural resins are water-clear and transparent.

Polycarbonate resins are available in general-purpose molding and extrusion grades and in special grades that...

...molding, weather and UV-resistance, glass-reinforcement, EMI, RFI, ESD-shielding, and structural-foam applications. **Polycarbonate** is also available in extruded sheet and film.

Properties: Polycarbonates are characterized by a combination...

...transition behavior and maintain high impact strength to 1/4 in. thick. A properly designed **polycarbonate** part, even in a thick section, has more impact resistance at -65[degrees]F than...

...of two to three in glass-reinforced compounds.

The insulating and other electrical characteristics of **polycarbonate** are excellent and almost unchanged by temperature and humidity conditions. One exception is arc resistance...
...temperature has no effect, but continuous exposure in hot (65[degrees]C) water causes gradual **embrittlement**. The resins are soluble in chlorinated hydrocarbons and are attacked by most aromatic solvents, esters ...

...and special coating systems can be applied to provide additional chemical protection.

Application: Injection-molded **polycarbonate** components in the electrical/electronics area include connectors, switches, face plates, terminal blocks, meter covers...

...door and window hardware. Premium-quality resins are used for compact audio discs.

Blow-molded **polycarbonate** products include returnable water and milk bottles, baby bottles, lighting globes, automotive spoilers, and drawer fronts for office furniture. Foam-molded **polycarbonate** parts include housings for computer terminals and copying machines, bus seats, roofs for recreational vehicles...

...highway-delineator guideposts, automotive bright trim, and flourescent-lighting luminaries.

A large volume use of **polycarbonate** is in clear extruded sheet, either in monolithic or laminated form, for safety and vandal-resistant windows in schools, ...to produce skylights, outdoor signs, interior aircraft parts, safety face shields, and recreational-vehicle windshields.

Polycarbonate resins are used extensively in alloys and blends. Mobay for example, produces compounded resins of **polycarbonate** with ABS, PET, and polyurethane elastomer.

Polyester

Polyester resins, in thermoset, glass-fiber-reinforced formulations, have been used for a variety of industrial, marine, and consumer products for at least 40 years. These are the materials of "fiberglass" boats, fishing rods, and automobile body panels. More recently, thermoplastic grades of polyesters have become available for use in high-performance, injection-molded parts.

Thermoset polyesters: Polyester and alkyd molding compounds are usually based on unsaturated polyester resin systems. The term alkyd refers to those using lower amounts of monomer; when the monomer level is higher, the compound is called a polyester. At room temperature, the solutions -- mixtures of resin and a liquid monomer (usually styrene) -- are stable. Any of a variety of peroxide catalysts can initiate crosslinking (curing) at room temperature or at higher temperatures.

Unlike most other plastics that are based principally on a single ingredient, polyester formulations usually contain substantial amounts of several materials. Special advantages and limitations apply to each type of poyester compound, and to the various processing methods.

Fabrication of parts from thermoset polyester resins -- usually glass-fiber-reinforced compounds -- is more varied than with any other type of plastic. Methods for producing polyester/glass-fiber (FRP) parts include hand lay-up and spray-up for small to moderate quantities of large parts; compression molding from sheet-molding compound or from glass-fiber

preforms for high-volume production of moderate-sized, intricates parts; cold-press molding for smaller components; pultrusion for constant-section shapes; and resin-injection molding, also called resin-transfer molding, a low-pressure method for intermediate production quantities.

Polyesters are also available as casting resins, both in water-extended formulations for low-cost castings, and in compounds filled with ground wood or pecan-shell flour for furniture components.

Low-profile molding resins are mixtures of polyester resins, thermoplastic polymers, and glass-fiber reinforcement. These are used to mold parts with smooth surfaces that can be painted without the need for prior sanding.

Bulk-molding compounds (BMC) are mixtures of polyester resin, short-glass fibers (1/8 to 1/4 in. long), filler, catalyst, and other additives for specific properties. BMC is supplied in bulk form or as extruded rope for ease of handling.

Sheet-molding compounds (SMCs) consist of polyester resin, long-glass fibers (to 2 in.), a catalyst, and other additives. They are supplied in rolls, sandwiched between polyethylene carrier films. Uniformity of SMC materials is closely controlled, making these materials especially suited for automated production.

Structural SMCs contain up to 65% glass in continuous, as well as random, fiber orientation. This compares with 20 to 35% glass, in random orientation only, of conventional SMC. For more details, see the chapter on thermoset composites.

Polyester resins are also available for use as coatings for curing by ultraviolet radiation. These 100%-solids materials cure in a matter of seconds and give off no solvents. Although some styrene may be lost upon exposure to UV radiation, the amount is small.

Properties: Properties of thermoset polyesters are so dependent on type, compounding, and processing method that a complete listing covering all combinations would be almost impossible. However, typical strength ranges obtainable in parts fabricated from various forms of polyester/glass compounds and processed by several methods are listed in the table.

Outdoor weatherability of polyester resins specifically compounded for such service is good. Thermal, electrical, and environmental properties are generally good and can be individually improved by formulation.

Applications: The three major application areas for fiberglass-reinforced polyesters are boat hulls, architectural panels, and transportation components. Other uses include swimming-pool filter bodies, athletic equipment, housings for industrial and office equipment, storage tanks, agricultural fertilizer and seed hoppers, stackable chairs and other furniture, and bath-room components such as shower stalls and modular tub-wall segments. Many automobile fron-end panels are made from glass-reinforced polyester in SMC form, by compression molding.

Pultruded parts include luggage racks for buses, boom arms for aerial lift trucks, and hollow (urethane-foam filled) insulating panels for structural uses. Pultruded structural shapes -- channels, beams, and solid rod -- containing up to 75% glass are replacing steel members in chemical processing equipment, where maximum corrosion resistance is essential.

Thermoplastic polyesters: Known chemically as polybutylene terephthalate (PBT) and polyethylene terephlalate (PET), the thermoplastic-polyester molding compounds are crystalline, high-molecular-weight polymers. They have an excellent balance of properties and processing charactistics and, because they crystallize rapidly and flow readily, mold cycles are short.

In addition to several unreinforced molding resins, the polyesters are available in glass-reinforced grades. Unreinforced and glass-filled grades are available with UL flammability ratings of 94 HB and 5V.

Properties: Thermoplastic polymers have excellent resistance to a

broad range of chemicals at room temperature including aliphatic hydrocarbons, gasoline, carbon tetrachloride, perchloroethylene, oils, fats, alcohols, glycols, esters, ethers, and dilute acids and bases. They are attacked by strong acids and bases.

High creep resistance and low-moisture absorption give the polyesters excellent dimensional stability. Equilibrium water absoroption, after prolonged immersion at 73[degrees]F, ranges from 0.25 ti 0.50% and, at 150[degrees]F, is 0.52 to 0.60%. Black-pigmented grades are recommended for maximum strength retention in outdoor uses.

Toughness is another strong point of the unreinforced, high-molecular-weight thermoplastic polymers. Unnotched specimens are rated "no-break" both at room temperature and at -40[degrees]F. In falling-dart tests, the unreinforced grades withstand more than 40 ft.lb. A toughened grade of 30% glass-reinforced resin has an unnotched impact strength of 24 ft-lb/in. -- about 40% greater than that of conventional 30% glass-reinforced polyesters. Although impact strength ...available, however, to reduce warpage. For applications requiring maximum toughness, an amorphous resin, such as **polycarbonate**, can be blended with the polyester. Warpage is also reduced considerably with the addition of...

...at 250[degrees]C. With no flame-retardant additives or halogens, PEEK has a limiting **oxygen** index of 35%, meets UL94V-0 requirements, and has extremely low smoke emission.

PEEK has good resistance to aqueous reagents, with long-term proven performance in water at 260[degrees]C. Resistance to attack is over a wide pH range, varying from 60% sulfuric acid to 40% sodium hydroxide at elevated temperatures. It is attacked, however, by some concentrated acids. No solvent attack has been observed on molded parts, although some solvents cause crazing of highly stressed PEEK-coated wire. Orientation of PEEK below its melting point overcomes this problem.

Preliminary tests suggest that radiation resistance is extremely good. Tightly coiled, PEEK-coated wire samples have withstood 1,100 megarads without significant degradation. Like more polyaromatic resins, PEEK moldings are degraded by UV exposure during outdoor weathering. The effect is minimal, however, over a 12-month period for both natural and pigmented moldings. For use in extreme weather conditions, paint or other coatings are recommended for protection from UV degradation.

Applications: Typical applications of PEEK thermoplastic resin include insulation for wire and cable for demanding applications involving aircraft, military, nuclear-plant, oil-well, and underground-railway equipment. Injection-molded applications include pump impellers, electrical connectors, valve seals, and fairing members for aircraft.

Polyetherimide

Polyetherimide (PEI) is an amorphous engineering thermoplastic characterized by high heat resistance, high strength and modulus, excellent electrical properties that remain stable over a wide range of temperatures and frequencies, and excellent processibility. Unmodified PEI resin is transparent and has inherent flame resistance and low-smoke evolution. The resin is produced by the General Electric Co. under the Ultem trademark.

Polyetherimide resin is available in an unreinforced grade for general-purpose injection molding, blow molding, foam molding, and extrusion, in four glass-fiber-reinforced grades (10, 20, 30, and 40% glass), in bearing grades, and in several high-temperature grades. The unreinforced grade is available as a transparent resin and in stadard and custom colors. Also available is an impact-modified Ultem sheet.

The resin can be processed on conventional thermoplastic molding equipment. Melt temperatures of 660 to 800[degrees]F are typical for injection-molding applications. Mold temperatures of 150 to 350[degrees]F are required.

Polyetherimide is extruded to produce profiles, coated wire, sheet, and film. Film ...016 in. and 94-5V at 0.075 in. without the use of additives. Limiting **oxygen** index is 47%, one of the highest among the engineering thermoplastics. Smoke evolution, as measured...

...in tensile strength after 1,000 h of xenon are exposure is negligible. Resistance to **gamma radiation** is also good, strength loss is less than 6% after 500 megarads exposure to cobalt...

...light transparency surgical instrument trays, staplers, and nebulizer components requiring repeated steam, chemical, or radiation **sterilization**. PEI is also finding uses in high-strength, heat and corrosion-resistant fluid and air-handling components, fasteners, and glass and graphite-fiber-reinforced composites.

Polyimide

Available both as thermoplastic and thermoset resins, polyimides (PIs) are a family of some of the most heat and fire-resistant polymers known. Moldings and laminates are generally based on thermoset resins, although some are made from thermoplastic grades. Unlike most plastics, PIs are available as laminates and shapes, molded parts, and stock shapes from some materials producers (Envex parts and shapes from Rogers; Vespel parts and shapes and Kapton film, from Du Pont; and Upilex film, from ICI) and as resins (powders and solutions) from others (Ciba-Geigy, Rhone-Poulenc, Rogers, Upjohn). Thin-film products -- enamel, adhesives, and coatings -- are usually derived from thermoplastic polyimide resins.

Laminates are based on continuous reinforcements including woven glass and quartz fabrics, or fibers of graphite, boron, quartz, or organic materials. Molding compounds, on the other hand, contain discrete fibers such as chopped glass or asbestors, or particulate fillers such as graphite powders, MoS.sub.2, or PTFE.

Polyimide films and wire enamels are generally unfilled. Coatings may be pigmented or filled with particles such as PTFE for lubricity. Most adhesives contain aluminum powder to provide a closer match to the thermal-expansion characteristics of metal substrates and to improve heat dissipation.

PI parts are fabricated by techniques that range from powder-metallurgy methods to conventional injection, transfer, and compression molding, and extrusion methods. Porous polyimide parts are also available. Generally, those compounds that are the most difficult to fabricate have the highest heat resistance.

Properties: Polyimide parts and laminates can serve continuously in air at 500 [degrees] F; service temperature for intermittent exposure can range from cryogenic to as high as 900[degrees]F. Glass-fiber-reinforced versions retain over 70% of their flexural strength and modulus at ...below 400[degrees]F. The resins are falem-retardant without additives (UL94V-0/5). The **oxygen** index of the resin is 44, and indexes of the compounds range from 47 to 53. Because flame retardance is inherent, regrind is as flame resistant as virgin material.

Mechanical properties of the various PPS compounds are tailored for target applications. The balance of properties can be controlled by the degree of crystallinity of a molded part. Amorphous moldings have optimum mechanical strength at room temperature, and crystalline moldings deliver optimum dimensional stability at high temperatures.

Applications: Principal applications of injection-molded PPS compounds are electrical/electronic and industrial mechanical equipment. The glass-reinforced compounds are used in telecommunications, computer, and electronic components such as connectors, coil forms, and bobbins. Glass-reinforced and mineral-filled compounds are better suited for higher power uses and structural components such as motor-brush holders requiring

UL direct-support rating.

PPS moldings are widely used in chemical and petroleum-processing equipment such as submersible centrifugal, vane, and gear-type pumps needing high strength and chemical resistance at high temperatures.

Many under-hood automotive components of PPS are in commercial production. Here, selection of PPS is based heavily on its resistance to the corrosive effects of hot exhaust gases, ethylene glycol, gasoline, and other automotive fluids.

In handheld and small appliances, heat-resistant PPS compounds offer the added feature of color. Typical applications include hair dryers, other personal-care items, and small cooking appliances. Blends with PTFE are also used for release coatings on molds, cookware, and industrial containers.

Components molded from PPS stampable sheet include housings for industrial pumps and meters, pipe fittings, aircraft seat backs and interior panels, and commercial heat exchangers.

Polystyrene

Noted for its sparkling clarity, hardness, ease of processing, and excellent colorability, polystyrene is a low-cost amorphous thermoplastic that often competes favorably with higher-priced resins. PS is available in a wide range of grades for injection molding, extrusion, and foam molding. Modifications to the basic, general-purpose PS resin include grades for high heat, and for various degrees of impact resistance. Clarity and gloss are reduced, however, in the impact grades.

Polymers in the styrene family include ABS and SAN, described in another chapter, and the styrene-maleic anhydride (SMA) copolymers. Structural characteristics of these resins are similar, but the SMA resins have the highest heat resistance.

Expandable polystyrene (EPS) is a specialized form of the resin used to make low-density (0.75 to 10.0 lb/ft) foam shapes and blocks. These materials are suited for thermal insulation and energy absorption. Copolymers of polystyrene formulated into EPS-type foamable resins provide improved heat tolerance, solvent resistant, or cushioning.

Expandable PS foams are produced in a two-stage process. The resin particles are first expanded to the density required in the finished item while remaining as discrete particles. In the second step, the foamed particles are placed in a vented mold of the final shape. Steam is forced into the mold, heating theparticles by direct contact and causing them to expand and fuse together to form a void-free, dry foam part. Pressures in the process are usually below 50 psi, allowing the use of relatively low-cost aluminum tooling.

Properties: Unmodified polystyrene is rigid and brittle, has moderate strength, and is crystal-clear. Impact strength is increased significantly by blending the polymer with rubbers such as polybutadiene.

Heat resistance is low compared to that of most thermoplastics; maximum recommended continuous-service temperature is well under 200[degrees]F. Electrical properties are good at room temperature and are affected only slightly by higher temperatures and varying humidity conditions.

Polystyrene is soluble in most aromatic and chlorinated solvents. It is insoluble in alcohols such as methanol, ethanol, normal heptane, and acetone. Most foods, drinks, and household fluids that have no effect on polystyrenes, but the resins are attacked by citrus-fruit-rind oil, gasoline, turpentine, and lacquer thinner.

Applications: General-purpose polystyrenes are used for knobs, light shields, disposable beverage glasses, serviceware, and packaging items. High-heat formulations are found in radio and TV cabinets, tape reels, and appliance parts. Impact grades are used in appliances, toys, housewares, and specialty items. Structural-foam polystyrene is used in

wood-replacement products such as "carved" components for furniture and, in extruded form, trim strips and baseboards for residential and mobile-home use.

EPS foams are used for heat insulation in the building industry and in appliances. The shock-absorbing characteristics make them useful for packaging products ranging from bottled cosmetics to electronics equipment. Foam blocks are used for protecting bumpers of new cars in shipment. Light weight and moisture resistance of the foam make it ideal for drinking cups and flotation products.

Molded EPS shapes are also used as expendable patterns for metal castings made by the "lost-foam," or "full-mold," process.

Styrene copolymers: A higher heat resistance distinguishes the styrene-maleic anhydride copolymers from their base styrenic and ABS families. The SMA copolymers have high molecular weights (200,000 to 250,000 average), and are processed by injection molding, extrusion, injection-blow molding, and extrusion-blow molding.

These resins have excellent melt rheology and flow characteristics at melt temperatures of 400 to 550[degrees]F and with mold temperatures of 120 to 150[degrees]F. Styrene copolymers set up rapidly and provide fast molding cycles. Processibility of both crystal clear and impact-modified copolymers is excellent. Heat properties, processing ease, and costs provide an excellent balance for cost-effective applications.

Crystal-clear SMA resins can be pigmented to produce a wide range of transparent, translucent, or opaque colors. Best results are obtained with ...molded, foamed and vinyl covered.

SMA-PC blends: Blends of styrene maleic anhydride copolymers and **polycarbonate** provide an excellent balance of processability and heat resistance, impact strength, and ductility. Large parts can be molded with fewer gates and lower tonnage machines because of their processibility, and small parts can be molded with pinpoint gates without loss of impact strength.

Properties: Heat resistance and impact strength at room and low temperatures are the primary attributes of SMA-PC blends. Deflection temperature under load (1/8-in. bars) ranges from 226 to 242[degrees]F. Gardner and notched Izod impact-strength values are 480 in.-lb and 10 to 12 ft.lb. These blends are also compounded with glass-fiber reinforcement for improved flexural modulus and heat resistance.

Applications: Automotive uses of SMA-PC blends include air-conditioner/heater ducts and grilles, radio-speaker grilles, decorative trim panels, glove-box doors, instrument-cluster housings, consoles, exterior trim panels, and wheel covers. Nonautomotive applications include computer and mobile telephone housings, surgical appliances, hospital feed trays, camera components, and portable electric-tool housings. Grades that meet requirements for food-contact applications are available.

POLYURETHANE

Extremely wide variations in forms and in physical and mechanical properties are available in polyurethanes. Grades can range in density from 0.5 [lb/ft.sup.3] in cellular form, to over 70 [lb/ft.sup.3] in solid form, and in hardness from rigid solids at 85 Shore D to soft, elastomeric compounds.

Polyurethane polymers, produced by the reaction of polyisocyanates with polyester or polyether-based resins can be either thermoplastic or thermosetting. They have outstanding flex life, cut resistance, and abrasion resistance. Some formulations are as much as 20 times more resistant to abrasion than metals.

The noncellular grades -- millable gums and viscous, castable, liquid urethanes -- are elastomeric thermoset types, processed by conventional rubber methods. These are discussed in the chapter, Thermoset rubber. Grades processed by thermoplastic methods are covered in the chapter,

Thermoplastic elastomers. This chapter discusses the cellular polyurethanes materials.

Polyurethane foams are thermoset materials that can be made soft and flexible or firm and rigid at equivalent densities. These foams, made from either polyester or polyether-type compounds, are strong, even at low density, and have good chemical resistance. Polyether-based foams have greater hydrolysis resistance, are easier to process, and cost less. Polyester-based foams have higher mechanical properties, better oil resistance, and more uniform cell structure. Both types can be sprayed, molded, foamed in place, or furnished as sheets cut from slab stock -- burns, 30 to 48 in. high, to 80 in. wide, and to 200 ft long.

A low-pressure modling process -- reaction-injection molding (RIM) is used almost exclusively to produce urethane parts -- some weighting as much as 100 lb. In the process, two or more highly reactive liquid systems are injected with high-pressure impingement mixing into a closed mold at low pressure, where they react to form a finished polymer. Depending on formulation, the polymer can be a rigid, integral-skin, microcellular urethane foam with a flexural modulus of over 100,000 psi, a soft, flexible elastomer with a flexural modulus as low as 7,000 psi, or a rigid structural foam having a density of 30 [lb/ft.sup.3]. Cycle time is short; parts can be demolded in less than a minute.

Reinforcement in the form of milled glass fiber, glass flake, or mineral filler increases the stiffness, thermal properties, and dimensional stability of RIM parts. Maximum glass content in reinforced reaction-injection molding (RRIM) is about 25% -- a limit determined by the increased viscosity with increasing glass. Natural color of unpigmented RIM urethane parts is tan.

Flexible foams: Glass-transition temperatures (the temperature at which an elastomeric material becomes stiff and brittle) of flexible foams is well below room temperature. The foams can be pigmented to any color but, regardless of pigmentation, they yellow when exposed to air and light. Some types of flexible foams are excellent liquid-absorbing media, and can hold up to 40 times their weight of water.

Polyether-type foams are not affected by high-temperature aging, either wet or dry, but UV exposure produces brittleness and reduces properties. In use, these foams are always covered with a fabric or other material.

Most solvents and corrosive solutions decrease tear resistance and tensile strength and cause swelling of flexible foams. Swelling is not permanent, however, if the solvent is removed and the foam dried. However, the foams can be destroyed by strong oxidizing agents and hydrolyzed in strong acids or bases. Generally, the polyether foams are more resistant to hydrolytic ...as 320[degrees]F. Even after prolonged exposure to such temperatures, the resins do not **discolor** or degrade. Thermal stability and oxidation resistance are excellent at service temperatures well above 300[degrees]F.

Heat aging of the polymers increases tensile strength, heat-deflection temperature, and modulus of elasticity appreciably. However, prolonged heat aging (about a year) decreases toughness, tensile strength, and elongation. Unnotched specimens of the sulfones are extremely tough and do not break in standard impact tests.

Electrical insulating properties are generally in the mid-range among those of other thermoplastics, and they change little after heat aging at the recommended service temperatures. Dissipation factor and dielectric constant -- and thus, loss factor -- are not affected significantly by increased temperature or frequency.

Creep of the sulfones, compared with that of other thermoplastics is exceptionally low at elevated temperatures and under continuous load. For example, creep at 210[degress]F is less than that of acetal or

heat-resistant ABS at room temperature. This excellent dimensional stability qualifies the sulfone resins for precision molded parts.

The hydrolytic stability of these resins makes them resistant to water absorption in aqueous acidic and alkaline environments. The combination of hydrolytic stability and heat resistance results in exceptional resistance to boiling water and steam, even under autoclave pressures and cyclic exposure of hot to cold and wet to dry.

The sulfones also share a common drawback: They absorb ultraviolet rays, giving them poor weather resistance. Thus, they are not recommended for outdoor service unless they are painted, plated, or UV stabilized.

Applications: The three sulfone resins are used in similar applications differing principally by the service temperature involved. Molded components include coil bobbins, multipin connectors, integrated-circuit carriers, power-module housings, hair-dryer grilles, hot-water valves, and business-machine brackets. Glass-reinforced grades are used in automotive under-hood parts such as switch housings and relay bases.

Molded sulfone parts are sterilizable by wet or dry heat or by gases. Applications are in medical instruments, respiration apparatus, filtration membranes, and medical implants. Food applications include steamtable pans, coffeemakers, hot-water tanks for beverage dispensers, and microwave cookware.

Polyether sulfone is also available as a film (ICI Films' Stabar) that offers the same high-temperature stability, chemical resistance, and electrical properties of molded PES components. Its low flammability and low smoke evolution during burning qualify Stabar film for use in aircraft interiors, power-module housings, and medical equipment. Other applications include xerographic transparencies, capacitor film, and flexible printed circuitry.

15/3,K/4 (Item 4 from file: 148)
DIALOG(R)File 148:Gale Group Trade & Industry DB

02825353 SUPPLIER NUMBER: 04209942 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Plastics. (Materials Reference Issue)
Machine Design, v58, p79(79)
April 17, 1986
ISSN: 0024-9114 LANGUAGE: ENGLISH RECORD TYPE: FULLTEXT
WORD COUNT: 36075 LINE COUNT: 03167

TEXT:

...polymer chemistry PLASTICS are a large group of materials consisting of combinations of carbon and **oxygen**, hydrogen, nitrogen, and other organic and inorganic elements. A plastic is solid in its finished state, but at some stage in its manufacture, it approaches a liquid condition and is capable of being formed into various shapes. Forming is most usually done through the application, either singly or together, of heat and pressure. More than 50 different families of plastics are in commercial use today, and each may have dozens of subtypes and variations.

... do not significantly improve strength at higher temperatures.

Examples of amorphous thermoplastics are ABS, polystyrene, **polycarbonate**, polysulfone, and polyetherimide. Crystalline plastics include polyethylene, polypropylene, nylon, acetal, polyethersulfone, and polyetheretherketone.

Copolymer structures...

...bottles, nylon gears and rollers, acrylic lenses, ABS business-machine housings, polystyrene-foam cups, and **polycarbonate** safety helmets and glazing sheet for bus windows.

The thermosets

Thermoset plastics are made quite differently from thermoplastics. Polymerization (curing) of thermoset plastics is done in two stages, partly by the material supplier and partly by the molder.

As illustrated in Fig. 4, phenolic (a typical thermoset plastic) is first partially polymerized by reacting phenol with formaldehyde under heat and pressure. The reaction is stopped at the point where mostly linear chains have been formed. The linear chains still contain unreacted portions, which are capable of flowing under heat and pressure.

The final stage of polymerization is completed in the molding press, where the partially reacted phenolic is liquefied under pressure, producing a crosslinking reaction between molecular chains. Unlike a thermoplastic monomer, which has only two reactive ends for linear chain growth, a thermoset monomer must have three or more reactive ends ...styrene (ABS) were the first to be introduced. Others available today include PVC/acrylic, ABS/**polycarbonate**, ABS/polysulfone, nylon/polystyrene, ABS/polyurethane, polyphenylene oxide/polystyrene, polyphenylene oxide/polystyrene/nylon, **polycarbonate**/polystyrene, nylon/polyolefin, and **polycarbonate**/polyester.

A new technology that combines incompatible polymers to form blends called interpenetrating polymer networks (IPNs) promises to provide cost/performance benefits not previously available in engineering plastics. Several companies are working on IPN development, but only a few have made developmental IPN materials available.

An IPN is a materials system consisting of two or more continuous polymer phases intertwined with each other and held together by permanent entanglements. The relationship is similar to that between small blood vessels and the surrounding tissue in the human body. Patented IPN technology by Shell Chemical Co. is based on the capability of the company's Kraton G thermoplastic elsatomer (styrene butadiene block copolymer) to form stable and reproducible structures when properly mixed in the melt stage.

The blends provide properties of the individual phases of the mixture and have few or no property losses that might be expected from combining incompatible materials. The results are materials having the best performance features of both an engineering thermoplastic and a thermoplastic rubber.

Although Shell is the first to come out with injection-moldable IPNs, other resin suppliers--Allied, Celanese, and Du Pont--are also working on similar materials. Research at Allied Corp., for example, is focused on combining the toughess of thermoplastics with the solvent resistance, heat resistance, and dimensional stability of thermoset resins. Allied researchers feel that, when the IPNs become fully commercial, they will likely be processed by reaction-injection molding (RIM), by injection molding with a post-molding oven cure, or by a sheet-molding process followed by a cure cycle.

Designed with plastics

A SUCCESSFUL design in plastics is almost always a compromise among high performance, attractive appearance, efficient production, and low cost. Achieving the best compromise requires satisfying the mechanical requirements of the part, utilizing the most economical resin or compound that will perform satisfactorily, and choosing a manufacturing process compatible with the part design and material choice. Setting realistic requirements for each of these areas is of utmost importance.

Choosing the most economical plastic for a part by comparing the cost per pound of various plastics is a mistake. Some plastics weigh twice as

much per cubic inch as others and so would require twice as much to fill a given cavity and cost twice as much to ship. A more meaningful comparison is cost per cubic inch. But since most expensive plastics are far stronger than the cheaper ones, cost/strength values should be analyzed as well. Paying more per pound or per cubic inch is often more economical if less material can be used to do the job.

Probably no plastic will provide 100% of the requirements for the desired performance, appearance, ...are compounded with other resins to achieve special properties. For example, ABS is alloyed with **polycarbonate** to achieve a better balance of heat and impact properties at an intermediate cost. Deflection temperature is improved by the **polycarbonate**; molding ease, by the ABS. Other ABS resins are used to modify rigid PVC for use in pipe, sheeting, and molded parts.

Related to ABS is SAN, a copolymer of styrene and acrylonitrile (no butadiene) that is hard, rigid, transparent, and characterized by excellent chemical resistance, dimensional stability, and ease of processing. SAN resins are usually processed by injection molding, but extrusion, injection-blow molding, and compression molding are also used. They can also be thermoformed provided that no postmold trimming is necessary. (Because the material is not toughened, thermoformed shapes may crack during conventional trimming operations.)

Properties

ABS plastics offer a good balance of tensile strength, impact and abrasion resistance, dimensional stability, surface hardness, rigidity, heat resistance, low-temperature properties, chemical resistance, and electrical characteristics. These materials yield plastically at high stresses, so ultimate elongation is seldom significant in design; a part usually can be bent beyond its elastic limit without breaking, although it does stress-whiten. While not generally considered flexible, ABS parts have enough spring to accommodate snap-fit assembly requirements.

Impact properties of ABS are exceptionally good at room temperature and, with special resin grades, at temperatures as low as -40 [deg.]F. Because of the plastic yield at high strain rates, impact failure is ductile rather than brittle. Also, the skin effect which, in other thermoplastics, accounts for a lower impact resistance in thick sections than in thin ones, is not pronounced in ABS materials. A long-term tensile design stress of 1,000 to 1,500 psi (at 73 [deg.]F) is recommended for most grades.

General-purpose ABS grades may be adequate for some outdoor applications (depending on design and performance requirements), but prolonged exposure to sunlight causes a color change and reduces surface gloss, impact strength, and ductility. Less affected are tensile strength, flexural strength, hardness, and elastic modulus. Pigmenting the resins black, laminating with opaque acrylic sheet, and applying certain coating systems provide resistance to weathering. For maximum color and gloss retention, a compatible coating of opaque, weather-resistant polyurethane can be used on molded parts. For weatherable sheet applications, ABS resins can be co-extruded with a compatible weather-resistant polymer on the outside surface.

ABS resins are stable in warm environments and can be decorated with durable coatings that require baking at temperatures to 160 [deg.]F for 30 to 60 min. Heat-resistant grades can be used for shortperiods at temperatures to 230 [deg.]F in light load applications. Low moisture absorption contributes to the dimensional stability of molded ABS parts.

Molded ABS parts are almost completely unaffected by water, salts, most inorganic acids, food acids, and alkalies, but much depends on time, temperature, and especially stress level. FDA acceptance depends to some extent on the pigmentation system used. The resins are soluble in ketones, and they soften or swell in some chlorinated hydrocarbons, esters,

aromatics, and aldehydes.

Properties of SAN resins are controlled primarly through acrylonitrile content and by adjusting the molecular weight of the copolymer. Increasing both improves physical properties, at a slight penalty in processing ease. Properties of the resins can also be enhanced by controlling orientation during molding. Tensile and impact strength, barrier properties, and solvent resistance are improved by this control.

Special grades of SAN are available with improved UV stability, vapor-barrier characteristics, and weatherability. The barrier resins--designed for the blown bottle market--are also tougher and have greater solvent resistance than the standard grades.

Applications

Molded ABS products are used in both protective and decorative applications in many indusrial and consumer products. Examples include safety helmets; camper tops; housings for small appliances, communications equipment, and business machines; automotive instrument panels and bumpers; pipe and pipe fittings; and home-security devices. Chrome-plated ABS has replaced die-cast metals in plumbing hardware and automobile grilles, wheel covers, and mirror housings.

Typical products vacuum-formed from extruded ABS sheet are refrigerator liners, luggage shells, tote trays, mower shrouds, boat hulls, and large components for recreational vehicles. Extruded shapes include weather seals, glass beading, refrigerator breaker strips, conduit and pipe and fittings for drain-waste-vent systems. Pipe and fittings comprise one of the largest single application areas for ABS.

Typical applications for molded SAN ...of hypochlorite ions. Solutions of 10% ammonium hydroxide, 3% hydrogen peroxide, and 10% sodium chloride **discolor** samples in prolonged immersion, but physical and mechanical properties are not significantly changed. Most organic...

...the conventional acrylics.

Properties

Acrylic plastics transmit and control light, resist weather, are stable against **discoloration**, and have superior dimensional stability and an excellent combination of structural and thermal properties.

Acrylic...

...These materials withstand exposure to light from fluorescent lamps without darkening or deteriorating. They ultimately **discolor**, however, when exposed to high-intensity UV light below 265 nm. Special formulations resist UV emission from light sources such as mercury-vapor and sodium-vapor lamps.

Applications

Applications for cast acrylic sheet include aircraft, boat, mass transit, architectural, and protective glazing; internally illuminating outdoor signs, lighting diffusers, and skylights; and product prototypes and demonstration models. Special ultraviolet-absorbing grades are used for document preservation in museums and ...materials are also characterized by excellent dimensional stability and resistance to moisture, chemicals, and liquid **oxygen**. They withstand strong and weak acids, alkalies, and organic solvents, even at elevated temperatures.

Electrical properties of allyl prepolymers include high surface and volume resistivity, low dissipation factor, and high arc resistance and dielectric strength.

Allyl moldings have low mold shrinkage and postmold shrinkage--attributed to their virtually complete addition reaction in the mold--and have excellent stability under prolonged or cyclic heat exposure. Allyls have high deflection temperatures and good creep resistance.

Advantages of allyl systems over polyesters are freedom from styrene

odor, low toxicity, low evaporation losses during evacuation cycles, no subsequent oozing or bleed-out, and long-term retention of electrical-insulation characteristics.

Applications

Allyl prepolymers are particularly suited for electronic gear for use in severe environmental conditions. Chemical inertness qualifies the resins for molded pump impellers and other chemical-processing equipment. Their ability to withstand steam environments permits uses in sterilizing and hotwater equipment. Because of their excellent flow characteristics, diallyl-phthalate compounds are used for parts requiring extreme dimensional accuracy. Modified resin systems are used for encapsulation of electronic devices such as semiconductors and as sealants for metal castings.

The largest single application area is electrical connectors, used in communications, computer, and aerospace systems. Uses for prepolymers include arc-track-resistant compounds for switchgear, and TV components. Other representative uses are insulators, encapsulating shells, potentiometer components, circuit boards, and housings.

Allyl-based prepregs are used to make lightweight, intricate parts such as radomes, printed-...corrosive liquids (diaphragms, valves, sight glasses); seals, gaskets, valve seats, and packings for liquid oxygen **and** hydrogen equipment; and flexible circuit laminations, wire insulation, jacketed cable, coil bobbins, and other electrical...

...not recommended for use in contact with ketones, esters, amines, and some organic acids. Oxygen **index** is 44.

Although electrical properties of PVDF are not as good as those of other...

...at 264 psi). Hardness of ETFE is Rockwell R50; that of ECTFE is R93.

Oxygen **index** of ETFE is 31; that of ECTFE is 60. (Oxygen-**index** ratings of PTFE, FEP, and CTFE are over 95.)

As with other fluoroplastics, these resins are compatible with most chemicals, even at high temperatures. ETFE is not attacked by most solvents to temperatures as high as 390[deg.]F. ECTFE is similar to 250[deg.]F, but is attacked by chlorinated solvents at higher temperatures. ETFE has better chemical stress-crack resistance.

Nylon

NYLONS (polyamides) were the first of the thermoplastic engineering resins. These crystalline plastics are available in many compositions, ranging from molding and extrusion materials to solution and fluidized-bed coatings and casting resins.

Nylon 6/6, the most widely used of the nylon plastics, is available in a number of formulations for molding and extrusion. Other general types are nylon 6/10 and nylon 6/12. These are higher priced materials, used where greater dimensional stability is required. Filled and reinforced compounds of most types are also available.

Nylon 6 is the second most widely used of the nylons. Its properties are similar to those of 6/6, but it absorbs moisture more rapidly and its melting point is 70[deg.]F lower. The lower processing temperature and the less crystalline nature of nylon 6 result in slightly lower mold shrinkage.

Nylons 11 and 12 have better dimensional stability and electrical properties than the other nylons because they absorb less moisture. These ...94 V-0 at thicknesses as low as 0.008 in. and has an oxygen **index** of 45%. Reinforced grades have surpassed FAA requirements for flammability, smoke density, and toxic gas...

...tensile strength drops only about 5% after exposure to 10.sup.9 rads of gamma **radiation**. **Chemical** resistance is good, the resin being

virtually unaffected by aliphatic and aromatic hydrocarbons, halogenated solvents...

...Inc., which concluded its second season of IMSA GT endurance racing in August, 1985.

Polycarbonate

POLYCARBONATES are high-molecular weight, amorphous engineering thermoplastics that have exceptionally high impact strength over a wide temperature range. Polycarbonate **resins** are produced in the U.S. principally by General Electric Co. (Lexan) and by Mobay...

...Corp. (Merlon). The Dow Chemical Co. has recently become the third domestic producer of polycarbonate **resins**.

The resins are available in general-purpose molding and extrusion grades and in several special...

...molding grades, weather and UV-resistant grades, glass-reinforced grades, and structural-foam grades. Polycarbonate **is** also available in extruded sheet. The natural resin is water-clear and transparent.

Properties

Polycarbonates...

...behavior, which maintain high impact strength to 1/4 in. thick. A properly designed polycarbonate **part**, even in a thick section, has more impact resistance at -65[deg.]F than most...

...at room temperature.

Humidity changes have little effect on dimensions or properties of molded polycarbonate **parts**. Even boiling water exposure does not change dimensions more than 0.001 in./in. after...

...two to three in glass-reinforced compounds.

The insulating and other electrical characteristics of polycarbonate **are** excellent and almost unchanged by temperature and humidity conditions. One exception is arc resistance, which...

...has no effect, but continuous exposure in hot (65[deg.]C) water causes gradual embrittlement. **The** resins are soluble in chlorinated hydrocarbons and are attacked by most aromatic solvents, esters, and...

...special coating systems can be applied to provide additional chemical protection.

Applications Injection-molded polycarbonate **components** in the electrical/electronics area include connectors, face plates, terminal blocks, telephone finger wheels, meter covers, business-machine housings, and computer-disk packs and storage modules. Typical appliance uses are power-tool housings, vacuum-cleaner ...oxygenators, solar-cell covers, boat-hatch covers, and door and window hardware.

Blow-molded polycarbonate **products** include returnable water and milk bottles, baby bottles, and lighting globes.

Foam-molded polycarbonate **parts** include housings for computer terminals and copying machines, bus seats, and roofs for recreational vehicles.

Profile-extruded products include patio-door thresholds, shelf rails, highway-delineator guideposts, automotive bright trim, and fluorescent-lighting luminaires.

A large volume use of polycarbonates is in clear extruded sheet, either in monolithic or laminated form, for safety and vandal-resistant windows in schools, self-service gas stations, banks, public buildings, trains and armored cars.

Sheet is thermoformed to produce skylights, outdoor signs, interior

aircraft parts, safety face-shields, and recreational-vehicle windshields.

Polyester

POLYESTER resins, in thermoset, glass-fiber-reinforced formulations, have been used for a wide variety of engineering components since the early days of World War II. They are the resins used in "fiberglass" boats, fishing rods, and automobile body panels. Only in recent years have thermoplastic grades of polyesters been available for use in high-performance, injection-molded parts.

Thermoset polyesters

Polyester resins of the thermosetting type are low-molecular-weight alkyd resins that are crosslinked with a monomer in a reaction initiated by a catalyst. At room temperature, the solutions--mixtures of resin and a liquid monomer (usually styrene)--are stable for months. Any of a variety of peroxide catalysts can initiate crosslinking (curing) at room temperature or at higher temperatures.

In contrast to most other plastics that are based principally on a single ingredient, polyester formulations usually contain substantial amounts of several materials. Special advantages and limitations apply to each type of polyester compound, and to the various processing methods.

Fabrication of parts from thermoset polyester resins--almost always glass-fiber-reinforced compounds--is more varied than with any other type of plastic. Methods for producing polyester/glass-fiber (FRP) parts include hand lay-up and spray-up for small to moderate quantities of large parts; compression molding from sheet-molding compound or from glass-fiber preforms for high-volume production of moderate-sized, intricate parts; cold-press molding for smaller components; pultrusion for constant-section shapes; and resin-injection molding, also called resin-transfer molding, a low-pressure method for intermediate production quantities.

Polyesters are also available as casting resins, both in water-extended formulations for low-cost castings, and in compounds filled with ground wood or pecan-shell flour for furniture components.

Low-profile molding resins are mixtures of polyester resins, thermoplastic polymers, and glass-fiber reinforcement. These are used to mold parts with smooth surfaces that can be painted without the need for prior sanding.

Bulk-molding compounds (BMCs) are mixtures of polyester resin, short glass fibers (1/8 to 1/4 in. long), filler, catalyst, and other additives for specific properties. BMC is supplied in bulk form or as extruded rope for ease of handling.

Sheet-molding compounds (SMCs) consist of polyester resin, long glass fibers (to 2 in.), a catalyst, and other additives, supplied in rolls, sandwiched between polyethylene carrier films. Uniformity of SMC materials is closely controlled, making these materials especially suited for automated production.

Structural SMCs contain up to 65% glass in continuous, as well as random, fiber orientation. (This compares with 20% to 35% glass, in random orientation only, of conventional SMC.) For more details, see the chapter on Reinforced Thermosets.

Polyester resins are also available for use as coatings for curing by ultraviolet radiation. These 100%-solids materials cure in a matter of seconds and give off no solvents. Although some styrene may be lost upon exposure to UV radiation, the amount is small.

Properties

Properties of thermoset polyesters are so dependent on type, compounding, and processing method that a complete listing covering all combinations would be almost impossible. However, typical strength ranges obtainable in parts fabricated from various forms of polyester/glass compounds, processed by several methods are listed in the table.

Outdoor weatherability of polyester resins specifically compounded

for such service is good. Thermal, electrical, and environmental properties are generally good, and can be individually improved, as needed, by formulation.

Applications

The three major application areas for fiberglass-reinforced polyesters are boat hulls, architectural panels, and transportation components. Other uses include swimming-pool filter bodies, athletic equipment, housings for industrial and office equipment, storage tanks, stackable chairs and other furniture, and bathroom components such as shower stalls and modular tub-wall segments. Most automobile front-end panels are now made from glass-reinforced polyester in SMC form, by compressing molding.

Pultruded parts include luggage racks for buses, boom arms for aerial lift trucks, and hollow (urethane-foam filled) insulating panels for structural uses. Pultruded structural shapes--channels, beams, and solid rod--containing up to 75% glass are replacing steel members in applications such as chemical processing equipment where corrosion resistance is essential.

Thermoplastic polyesters

Thermoplastic polyesters are crystalline engineering resins known chemically as polybutylene terephthalate (PBT) and polyethylene terephlalate (PET).

Thermoplastic-polyester molding compounds are crystalline, high-molecular-weight polymers that have an excellent balance of properties and processing characteristics. Because they crystallize rapidly and flow readily, mold cycles are short.

In addition to several unreinforced molding resins, the polyesters are available in glass-reinforced grades. Unreinforced and glass-filled grades are available with UL flammability ratings of 94 HB, and 5V.

Properties

Thermoplastic polyesters have excellent resistance to a broad range of chemicals at room temperature including aliphatic hydrocarbons, gasoline, carbon tetrachloride, perchloroethylene, oils, fats, alcohols, glycols, esters, ethers, and dilute acids and bases. They are attacked by strong acids and bases.

High creep resistance and low moisture absorption give the polyesters excellent dimensional stability. Equilibrium water absorption, after prolonged immersion at 76[deg.]F ranges from 0.25 to 0....in. and 94-5V at 0.075 in. without the use of additives. Limiting oxygen **index** is 47, one of the highest among the engineering thermoplastics. Smoke evolution, as measured in the NBS chamber test (ASTM E662), is low.

Dielectric constant remains virtually unchanged between frequencies of 60 and 10.sup.9 Hz and temperatures of 73 to 180[deg.]F. Good insulative capabilities are demonstrated by the high volume resistivity of 6.7 X 10.sup.17 ohm-cm and dielectric strength ranging from 620 V/mil at 1/16 in. to greater than 6,500 V/mil for submil film thicknesses. Arc resistance exceeds 120 s, meeting one of the UL electrical requirements for sole support of live parts.

At 356[deg.]F, the tensile strength and flexural modulus of polyetherimide are 6,000 and 300,000 psi, respectively. Moduli and strengths of the glass-reinforced grades are still higher. For example, flexural modulus is 1,200,000 psi with 30% glass reinforcement, and more than 80% of this is retained at 356[deg.]F.

Polyetherimide has good crepe resistance as indicated by its apparent modulus of 350,000 psi after 1,000 h at 180[deg.]F under an initial applied load of 5,000 psi. Gardner impact strength is in excess of 320 in.-lb at room temperature. The resin is notch sensitive, however, so sharp corners and other stress concentrations should be minimized for maximum impact resistance. Tensile elongation at yield of 8% provides the necessary

ductility for snap-fit designs.

Polyetherimide resists a broad range of chemicals under varied conditions of stress and temperatures. Compatibility has been demonstrated with aliphatic hydrocarbons and alcohols including gasoline and gasohol, mineral-salt solutions, dilute bases, and fully halogenated hydrocarbons. Resistance to mineral acids is outstanding. The polymer ...tensile strength after 1,000 h of xenon arc exposure is negligible. Resistance to gamma **radiation is** also good, strength loss is less than 6% after 500 megarads exposure to cobalt 60...

...250[deg.]C. With no flame-retardant additives or halogens, PEEK has a limiting oxygen **index** of 35%, meets UL 94V-0 requirements, and has extremely low smoke emission.

PEEK has good resistance to aqueous reagents, with long-term proven performance in water at 260[deg.]C. Resistance to attack is over a wide pH range, varying from 60% sulfuric acid to 40% sodium hydroxide at elevated temperatures. It is attacked, however, by some concentrated acids. No solvent attack has been observed on molded PEEK parts, although some solvents cause crazing of highly stressed PEEK-coated wire. Orientation of PEEK below its melting point overcomes this problem.

Preliminary tests suggest that radiation resistance of PEEK is extremely good. Tightly coiled PEEK-coated wire samples have withstood 1,100 megarads without significant degradation. Weathering resistance of PEEK is currently under evaluation; after one year of outdoor exposure, tests show no loss of properties.

Applications

Typical applications of PEEK thermoplastic resin include insulation for wire and cable for demanding applications involving aerospace, military, nuclear-plant, oil-well, and underground-railway equipment. Injection-molded applications include pump impellers, electrical connectors, and valve seals.

Polyimide

POLYIMIDES are a family of some of the most heat and fire-resistant polymers known. Their excellent retention of mechanical and physical properties at high temperatures is due to the nature of the aromatic raw materials that are building blocks of polyimides.

Polyimides are formulated as both thermosets and thermoplastics. Moldings and laminates are generally based on thermoset resins, although some are made from thermoplastic grades. Unlike most plastics, polyimides are available as laminates and shapes, molded parts, and stock shapes from some materials producers (Vespel parts and shapes, from Du Pont), and as resins from others. Thin-film products--enamel, adhesives, and coatings--are usually derived from thermoplastic polyimide resins.

Laminates are based on continuous reinforcements including woven glass and quartz fabrics, or fibers of graphite, boron, quartz, or organic materials. Molding compounds contain discrete fibers such as chopped glass or asbestos, or particulate fillers such as graphite powder, MoS.sub.2., or PTFE.

Polyimide films and wire enamels are generally unfilled. Coatings may be pigmented or filled with particles such as PTFE to add lubricity. Adhesives generally contain aluminum powder to provide a closer match to the thermal-expansion characteristics of metal substrates and to improve heat dissipation.

Polyimide parts are fabricated by techniques that range from powder-metallurgy methods to conventional injection, transfer, and compression molding, and extrusion methods. Porous polyimide parts are also available. Generally, those compounds that are the most difficult to fabricate have the highest heat resistance.

Properties

Polyimide parts and laminates can operate continuously in air at 500[deg.]F; service temperature for intermittent exposure can range from cryogenic to as high as 900[deg.]F. Glass-fiber-reinforced versions retain over 70% of their flexural strength and modulus at 480[deg.]F. Creep is almost nonexistent, even at high temperatures, and deformation under load (4,000 psi) is less than 0.05% at room temperature for 24 h.

These materials ...F.

Polyphenylene sulfide compounds are flame-retardant without additives (UL 94V-0/5V). The oxygen **index** of the resin is 44, and indexes of the compounds range from 47 to 53. Because flame retardances is inherent, regrind is as flame resistant as virgin material.

Mechanical properties of the various PPS compounds are tailored for target applications. The balance of properties can be controlled by the degree of crystallinity of a molded part. Amorphous moldings have optimum mechanical strength at room temperature, and crystalline moldings deliver optimum dimensional stability at high temepratures.

Applications

Principal applications of injection-molded PPS compounds are electrical/electronic and industrial mechanical equipment. The glass-reinforced compounds deliver the highest mechanical strength. Their low-loss insulation properties suit them for uses in telecommunications, computer and electronic components such as connectors, coil forms, and bobbins. Glass-reinforced and mineral-filled compounds are better suited for higher power uses and structural components such as motor-brush holders requiring UL direct-support rating.

PPS moldings are widely used in the chemical and petroleum processing industries for equipment such as submersible, centrifugal, vane, and gear-type pumps needing high strength and chemical resistance at high temperatures.

Many under-the-hood automotive components of PPS are in commercial production. Here, selection of PPS is based heavily on its resistance to the corrosive effects of hot exhaust gases, ethylene glycol, gasoline, and other automotive fluids.

In hand-held and small appliances, heat-resistant PPS compounds offer the added feature of color. Typical applications include hair dryers, other personal-care items, and small cooking appliances. Blends with PTFE are also used for release coatings on molds, cookware, and industrial containers.

Polystyrene

POLYSTYRENE is a low-cost thermoplastic noted for its sparkling clarity, hardness, and ease of processing. Colorability is excellent. It is available in several grades to suit various applications and processing requirements.

Modifications to the basic, general-purpose resin include grades for high heat, and for various degrees of impact resistance. Clarity and gloss are reduced, however, in the impact grades.

Other polymers in the styrene family are ABS and SAN, described in another chapter, and the styrene-maleic anhydride copolymers. The copolymers are as rigid as ABS and polystyrene but have better thermal properties.

Polystyrene is processed by many methods including injection molding, injection and extrusion blow molding, thermoforming, sheet and profile extrusion, structural-foam molding, and direct injection foam sheet.

Properties

Unmodified polystyrene is rigid and brittle, has moderate strength, and is crystal-clear. Impact strength is increased significantly by blending the polymer with rubbers such as polybutadiene.

Heat resistance is low compared to that of most thermoplastics; maximum recommended continuous-service temperature is well under ...

package, and other controls.

SMA-PC blends

Blends of styrene maleic anhydride copolymers and polycarbonate **have** been compounded to provide an excellent balance of processibility and heat resistance, impact strength, and ductility. Large parts can be molded with fewer gates and lower tonnage machines because of their processibility, and small parts can be molded with pinpoint gates without loss of impact strength.

Properties

Heat resistance and impact strength at room and low temperatures are the primary attributes of SMA-PC blends. Deflection temperature under load (1/8-in. bars) ranges from 226 to 242[deg.]F. Gardner and notched lzod impact strength values are 480 in.-lb and 10 to 12 ft-lb respectively. These blends are also compounded with glass-fiber reinforcement for improved flexural modulus and heat resistance.

Applications

Automotive uses of SMA-PC blends include air-conditioner/heater ducts and grilles, radio speaker grilles, decorative trim panels, glove-box doors, instrument-cluster housings, consoles, exterior trim panels, and wheel covers. Nonautomotive applications include computer and mobile telephone housings, surgical appliances, hospital feeding trays, camera components, and portable electric tool housings. Grades that meet requirements for food-contact applications are available.

Polyurethane

(cellular forms)

POLYURETHANES, polymers that, in various forms, are classified either as plastics or elastomers, offer extremely wide variations in physical and mechanical properties. They can range in density from 0.5 lb/ft.sup.3 in cellular form, to over 70 lb/ft.sup.3 in solid form, and in hardness from rigid solids at 85 Shore D to soft, elastomeric compounds.

Urethane polymers can be either thermoplastic or thermosetting types. They are produced by the reaction of polyisocyanates with polyester or polyether-based resins. In general, polyester types have higher mechanical properties, and polyether types, greater resilience. Polyurethanes have outstanding flex life, cut resistance, and abrasion resistance. Some are as much as 20 times more resistant to abrasion than metals.

The noncellular grades -- millable gums and viscous, castable, liquid urethanes -- are elastomeric thermoset types, processed by conventional rubber methods. These are discussed in the chapter, Rubber. Grades processed by thermoplastic methods are covered in the chapter, Thermoplastic Elastomers. This chapter discusses the cellular polyurethane materials.

Polyurethane foams are thermoset materials that can be made soft and flexible or firm and rigid at equivalent densities. These foams, made from either polyester or polyether-type compounds, are strong, even at low density, and have good chemical resistance. Polyether-based foams have greater hydrolysis resistance, are easier to process, and cost less. Polyester-based foams have higher mechanical properties, better oil resistance, and more uniform cell structure. Both types can be sprayed, molded, foamed in place, or furnished as sheets cut from slab stock -- buns, 30 to 48 in. high, to 80 in. wide, and to 200 ft long.

A low-pressure molding process -- reaction-injection molding (RIM) produces large (to 100 lb), integral-skin, foamed parts in either elastomeric or rigid urethanes. Cycle time is short; parts can be demolded in less than a minute.

Reinforcement, usually in the form of milled glass fiber, increases the stiffness and dimensional stability of ...320[deg.]F. Even after prolonged exposure to such temperatures, the resins do not discolor **or** degrade. Thermal stability and oxidation resistance are excellent

at service temperatures well above 300[deg.]F.

Heat aging of the polymers increases tensile strength, heat-deflection temperature, and modulus of elasticity appreciably. However, prolonged heat aging (about a year) decreases toughness, tensile strength, and elongation. Unnotched specimens of the sulfones are extremely tough and do not break in standard impact tests.

Electrical insulating properties are generally in the mid-range among those of other thermoplastics, and they change little after heat aging at the recommended service temperatures. Dissipation factor and dielectric constant--and thus, loss factor--are not affected significantly by increased temperature or frequency.

Creep of the sulfones, compared with that of other thermoplastics is exceptionally low at elevated temperatures and under continuous load. For example, creep at 210[deg.]F is less than that of acetal or heat-resistant ABS at room temperature. This excellent dimensional stability qualifies the sulfone resins for precision molded parts.

The hydrolytic stability of these resins makes them resistant to water absorption in aqueous acidic and alkaline environments. The combination of hydrolytic stability and heat resistance results in exceptional resistance to boiling water and steam, even under autoclave pressures and cyclic exposure of hot to cold and wet to dry.

The sulfones also share a common drawback: They absorb ultraviolet rays, giving them poor weather resistance. Thus, they are not recommended for outdoor service unless they are painted, plated, or UV stabilized.

Applications

Applications for the sulfone resins are similar, differing principally by the service temperature involved. Molded components include coil bobbins, connectors, integrated-circuit carriers, power-module housings, hair-dryer grilles, hot-water valves, and brackets in business machines. Glass-reinforced grades are used in automotive under-the-hood parts such as switch and relay bases.

Molded sulfone parts, which are sterilizable by wet or dry heat or by gases, are used in medical instruments, respiration apparatus, filtration membranes, and medical implants. Food applications include steamtable pans, coffeemakers, hot-water tanks for beverage dispensers, and microwave cookware. Extruded sheet and film are used for color xerographics transparencies, capacitor film, and flexible printed circuitry.

Advanced composites

WHILE carbon-fiber/epoxy-matrix composites are classified as reinforced thermosets, a special technology has developed involving these materials that sets them somewhat apart from other reinforced thermosets. These materials, called "advanced composites," can also include hybrids, consisting of mixtures of carbon and glass fibers in various forms, in the resin (almost always epoxy) matrix.

Carbon fibers can be long and continuous, or short and fragmented; they can be directionally or randomly oriented. Each fiber form has its advantages and limitations. In general, short fibers cost the least, and fabrication costs are lowest; but properties of the resulting composite are lower than those obtainable with longer or continuous fibers.

* Milled fibers are the shortest carbon fibers used for reinforcement. They range in length from 30 to 3,000 microns, averaging approximately 300 microns. Mean LD ratio is 30.

* Short chopped fibers (about 1/4-in. long), with an LD ratio of about 800, increase strength, and modulus of a composite more than milled fibers do. Cost of a molding compound reinforced with 1/4-in. fibers is about twice that of one containing milled carbon fibers.

* Long chopped fibers (to 2 in.) are often added to a thermosetting glass/polyester sheet-molding compound (SMC) to enhance the stiffness of compression-molded parts.

* Continuous carbon fibers provide the ultimate in performance and/or weight reduction. Continuous fibers are available in a number of forms including yarns or tows containing 400 to 160,000 individual filaments; unidirectional, impregnated tapes up to 48-in. wide; multiple layers of tape with individual layers, or plies, at selected fiber orientation; and fabrics of many weights and weaves.

Properties

The individual carbon-filaments, which are the basic elements of the reinforcement, are usually 10 microns or less in effective diameter. Tensile strength can exceed 800,000 psi, and modulus, 120 X 10.sup.6 psi. Commercial fibres are available in four modulus ranges: 30 to 35 million psi, 50 to 55 million psi, 70 to 75 million psi, and 100 to 120 million psi.

The outstanding design properties of carbon fiber/resin matrix composites are their high strength-to-weight and stiffness-to-weight ratios. With proper selection and placement of fibers, the composites can be stronger and stiffer than equivalent thickness steel parts and weigh 40 to 70% less. Fatigue resistance of continuous-fiber composites is excellent, and chemical resistance is better than that of glass-reinforced systems, particularly in alkaline environments.

Stiffness of a component can be varied significantly in different areas by selection of various types and forms of fiber, by judicious orientation, and by controlling local concentrations of fibers.

Like most rigid materials, carbon-fiber composites are relatively brittle. The composites have no yield behavior, and resistance to impact is low.

Thermal characteristics of carbon fibers are different from those of almost all other materials. Linear expansion coefficients range from slightly negative for 30-million-psi modulus fibers to approximately -1.... high-temperature steam, concentrated sulfuric acid, and boiling caustic materials.

Xydar resins have an oxygen **index** of 42 to 47. When exposed to open flame, the material forms an intumescent char...

...characteristics. Polypropylene applications include automotive air-cleaner housings and dishwasher tubs and inner doors. Polycarbonate **is** used in housings for water meters and power tools. Polyester applications include motor components--brush holders and fans--high-voltage enclosures, TV tuner gears, electrical connectors, and automobile exterior panels. Camper ...lubricants also allow the use of poor wearing, but high accuracy materials, such as polycarbonate, **in** gear or bearing applications. Lubricants can be used by themselves or in conjunction with glass...

...reinforcements.

Reinforced and/or internally lubricated compounds are used in a variety of applications. Polycarbonate-**based** compounds are used for gear and bearing surfaces where accuracy is important and chemical resistance is not a severe problem such as in cameras and office equipment. Acetal and PPS-based compounds have found wide acceptance in hostile environments such as gasoline metering and pumping devices. Nylon compounds are often chosen for certain harsh environments because of their excellent chemical resistance.

Reinforced thermosets

REINFORCED thermosets offer properties and cost/performance benefits considerably beyond those available in the unreinforced resins. Tensile, flexural, and impact strengths are higher; dimensional stability is greater, and the composite materials are still lighter than most metals.

Many combinations of materials provide a wide range of mechanical and

electrical properties, chemical resistance, as well as different surface appearance of molded parts. Properties are modified by reinforcements, fillers, catalysts, stabilizers, pigments, and fire retardants. Other additives affect processing characteristics.

Resin systems

More than 95% of reinforced thermoset parts are based on polyester and epoxy resins; of the two, polyester systems predominate in volume by far. Other thermoset resins used in reinforced form are phenolics and silicones.

Polyesters can be molded by any process available for thermosetting resins. They can be cured at room temperature and atmospheric pressure, or at temperatures to 350[deg.]F and under higher pressure. These resins offer a balance of low cost and ease of handling, along with good mechanical, electrical, and chemical properties, and dimensional stability. Polyesters can ...ABS. Also available in formulations for foam molding are engineering thermoplatics such as nylon, polycarbonate, **modified** phenylene oxide, polyester, and polysulfone. A number of resins are also available in glass-reinforced formulations.

Applications for structural-foam parts molded from the engineering resins extend beyond the wood-...folding, and others. Bulletin 800-8. ICI Americas Film Div., Wilmington, DE 19897

Styrene/polycarbonate **blend**

Opaque and crystal-clear formulations of Arloy resin are described in this product brochure. Engineering...

...P20A-848. Arco Chemical Div., Atlantic Richfield Co., 1500 Market St., Philadelphia, PA 19101

Polycarbonate **resins**

Six-page fold-out brochure describes Calibre **polycarbonate resin** grades suited particularly for medical and health-care applications requiring sterilization **by** steam or ethylene oxide. Full-page table lists physical, thermal, electrical, and mechanical properties, as...

...4 pages. Bunnell Plastics Inc., I-295 & Harmony Rd., Mickleton, NJ 08056

Product literature

Polycarbonate/**ABS** blend

Eight grades of polycarbonate/**ABS** Bayblend resins for molding applications are detailed in this extensive, 24-page design manual. Structural-design section covers both short and long-term properties. Calculations are provided for external loading effects, beams, and plates. Design-details section focuses on gating, section thickness, ribs, air trapping/venting, weld lines, appearance, and other pertinent considerations. Glossary is included as a handy reference. Bulletin 55-B585(3)J. Plastics Div., Mobay Chemical Corp., Mobay Rd., Pittsburgh, PA 15205

Special phenolics

This 50th Anniversary Brochure is a comprehensive listing of company's materials and their properties. Product listings include general-purpose phenolics, impact phenolics, specialty phenolics (heat) resistant, special, and electrical phenolics), carbon-graphite, melamine-phenolics, and polyesters. The easy-to-read charts cover typical values and give detailed data on properties (by compression, transfer, and injection molding), electrical performance, and other pertinent values. Plastics Engineering Co., Box 758, Sheboygan, WI 53082

Polyether block imides

Technical data brochure provides detailed physical property charts, chemical resistance guides, comparison data for similar materials, application ideas, and conversion techniques. Processing methods covered

include injection molding, extrusion blow molding, extrusion, thermoforming, and rotational molding. Polymers Div., Atochem Inc., Box 607, Glen Rock, NJ 07452

Liquid crystal polymer

Detailed, ten-page brochure describes performance properties of Xydar--an injection-moldable wholly aromatic thermoplastic featuring densely packed, fibrous polymer chain self-reinforcement. Charts, graphs, and discussions give full information on heat resistance, thermal stability, continuous use, toughness, and resistance to creep, stress, and solvents. Dartco Manufacturing Inc., Box 5867, Augusta, GA 30906

Reinforced polypropylenes

"Engineering Polypropylene" is a six-page foldout brochure introducing various grades of materials offering high flexural modulus, impact strength, dimensional stability, and ease of processing. Brochure includes a detailed comparison table that groups products by extrusion grades, injection-molding grades, and flame-retardant grades. Discussion covers potential applications, material characteristics, and technical data. Norchem inc., Norchem Center, Omaha, NE 68102

Polyethermide properties

Full-page tables list properties ...Brochure E-9020, 12 pages. EGC Corp., Box 16080, Houston, TX 77222

Designing with polycarbonate

Thirty-page design manual discusses selection of the right Lexan polycarbonate **resin** among several general-purpose, specialty, and glass-reinforced grades. Mechanical, thermal, and electrical properties are detailed in tables, charts, and diagrams of how tests are conducted. Assembly techniques, design recommendations, and prototyping methods are described. Publication CDC 536D. Plastics Group, General Electric Co., 1 Plastics Ave., Pittsfield, MA 01201

Product literature

Reinforced thermosets

"Engineering Thermosets" is an eight-page brochure covering the physical, molding, and performance properties of fiber-reinforced diallyl phthalate and phenolic molding compounds for automotive, electronic, and electrical uses. Discussions cover mechanical, electrical, and thermal properties, chemical compatibility, and suggested applications. Photograph shows results of creep testing on various materials. Bulletin 8135-035-60. Molding Materials Div., Rogers Corp., Box 550, Manchester, CT 06040

Fiberglass insulation components

Revised color brochure includes six pages of fiberglass/epoxy, polyimide, silicone, and paper/phenolic insulation components in ready-to-use or custom shapes.

Ready-to-use shapes include potting forms, coil bobbins, structurals, micro tubes, coil-form tubing, circuit-board stiffeners and ribs, and rod stock. Typical properties, stock mandrels, specifications, and tolerances are detailed, Form 285. Stevens Products Inc., 128 N. Park St., East Orange, NJ 07019

Properties of polycarbonates

Flowability, productivity, cost, and strength are some of the perfomance features of Merlon polycarbonates emphasized in this brochure. Discussion details rapid mold cycle time, processing benefits, equipment, strength characteristics, secondary operations, decorating and printing, and increasing output. 55-A5360, 16 pages. Plastics Div., Mobay Chemical Corp., Mobay Rd., Pittsburgh, PA 15205

Polyester alloys

Bulletin 2308-057 introduces a family of Gafite glass-filled polybutylene terephthalate (PBT) alloys formulated to improve the surface finish of molded parts and to offer high heat deflection temperatures, high tensile and impact strength, and smooth surface finishes. Chemical,

physical, mechanical, and molding properties are illustrated in a comprehensive chart in this four-page guide. Chemical Div., GAF Corp., 1360 Alps Rd., Wayne, NJ 07470

Composite tubes, pultrusions

"Craftsmanship in Precision Engineered Composites" explains company's ability to provide precision reinforcing fiber alignment to meet design needs. Individual sheets in this folder detail pultruded shapes and bar stock, reinforced composite tubes, double insulation, circuit-board edgers, cylinder tubing, and self-lubricating bearings. Filament weaving, pultrusion, and machining capabilities are covered. Polygon Co., Box 176, Walkerton, IN 46574

Carbon-fiber-reinforced thermoplastics

Bulletin 222-683 details cost and performance advantages of Thermocomp carbon-fiber-reinforced thermoplastic composites. This six-page foldout brochure consists of a detailed design property chart presenting composites based on several engineering plastics and listing physical, mechanical, thermal, tribological, electrical, and chemical properties. Case history describes a successful pump application. LNP Corp., 412 King St., Malvern, PA 19355

Product literature

Dip-molded parts

"Low-Cost Plastic Parts by Dip-Molding" illustrates several examples of the range of technology and applications available with this process for making dip-molded PVC parts. Tooling, design characteristics, material characteristics, sample service, material properties, and prototype capabilities are highlighted. Discussion also covers special formulations for modifying for tensile strength, resilience, toxicity, density, and other characteristics. 6 pages. Plastic Dip Moldings Div., Arbonite Corp., Box 949, Doylestown, PA 18901

UHMW polyethylene

"UHMW Polymer Product Guide" provides eight pages of details on specific properties, case histories, material comparisons, and molding processes. Color photographs illustrate typical parts, industrial applications, and over 40 variations of form and color. Comparison charts detail mechanical properties, sand slurry abrasion, friction coefficients, chemical resistance, and machining guidelines. Inserted article reprints give further data on performance and wear properties. Plastics Div., American ...of 16 plastics. Included in the listing are ABS, acetal, polyethylene, polypropylene, polysulfone, polyetherimide, polycarbonate, **and** others. The company's extruding, compression-molding, and annealing facilities are described, and its large inventory is emphasized. Westlake Plastics Co., P.O. Box 127, Lenni, PA 19052

Vinyl dispersions

Reference guide discusses plasticized PVC for use as a protective coating in highly corrosive and abrasive environments. Discussion covers addition of various agents to achieve specific characteristics, ranges of viscosity, and wear properties of dipped or sprayed coatings. Data tables categorize cured characteristics, chemical resistance, and burning characteristics. 10 pages. Arbonite Corp., Box 888, Doylestown, PA 18901

Thermoplastic resins

"Unique Engineering Thermoplastic Resins Designed for Automotive Applications" is a comprehensive guide to production technology, resin characteristics, and other pertinent topics. Chapters cover features and advantages of Pulse thermoplastic resins, company processing capabilities, current and future resin products, performance and physical properties, additives, and processing considerations. Form 301-828-286, 28 pages. Engineering Thermoplastics Dept., Dow Chemical U.S.A., 2040 Willard H. Dow Center, Midland, MI 48674

Advanced thermoplastic composites

This 12-page brochure details specific advantages and applications of Ryton polyarylene sulfide composites in military aircraft, missile, commercial aircraft, and helicopter applications. Discussion explains how the combination of the thermoplastic resin and long-fiber reinforcing agents provide a high strength composite with high temperature resistance, corrosion resistance, and other features. Thermoplastic Composites, Phillips Petroleum Co., Bartlesville, OK 74004

Graphite/epoxy composites

"Advanced Composites: New Flexibility for Design Engineers" is a six-page brochure highlighting the properties of these lightweight, corrosion-proof materials for aerospace and industrial uses. Color photos illustrate typical applications, including marine instrument housing, printing-press rollers, radar-dish elements, airborne electronic enclosures, and others. Sections covering engineering and design services, prototype and manufacturing process development, and composite structure manufacture list many current and potential applications. Bulletin 1064. Advanced Composite Products Inc., 37 Washington Ave., East Haven, CT 06512